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An Overview of IoT Based Smart Home Surveillance and Control System: Challenges and Prospects

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KEYWORDS

Internet of Things
Smart Security System
Smart Home Automation

ABSTRACT

Security plays an important role in our everyday lives be it in a personal, residential, commercial or enterprise setting. In the traditional home security setting, user can retrieve the video captured from the closed-circuit television (CCTV) when needed. However, user will not be notified when there is intruder. This disadvantage can be overcome by inculcating the idea of Internet of Things (IoT) into home security system. Smart home security system can integrate various types of sensors such as motion sensor, humidity sensor and temperature sensor together with electrical appliances in house such as CCTV camera, lights and fans. Smart home security system is capable to send notification to alert user if detected any house scenario which is abnormal so that user can act immediately upon receiving the notification for appropriate action. This helps to ensure the security of house. There are various home security systems proposed by past researchers. Therefore, this paper aims to provide a comprehensive review on the proposed designs and to analyse and compare the results to determine the challenges and prospect in this field of technology.

1. INTRODUCTION

Following the growth of economic over the past decade, the increase in urbanization rate has led to rising demand of home security system among consumers. It is forecasted that the global home security market size may expand at Compound Annual Growth Rate (CAGR) of 8.2% in the next 5 years, from USD 56.9 Billion in year 2022 to USD 84.4 billion in year 2027 [1]. The illustration of this prediction is shown as Figure 1. Along with advancement in technology, most of the device and protocol levels issues were solved, which contributes to the adoption of the Internet of Things (IoT) concept on home security system [2]. The IoT concept was first introduced in year 1999 to track products through supply chain by integrating radio frequency identification (RFID) chips [3]. This concept is now widely applied on integrating multiple sensors or actuators on a network to control and monitor them remotely.

Smart home security system refers to home security system that has been built based on the concept of IoT.

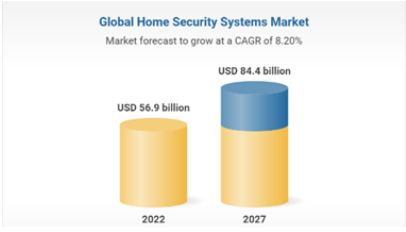

Fig 1. Forecasted global home security system market from year 2022 to year 2027 [1].

This system is highly customizable as it allows user to connect different type of devices such as camera module, motion sensor or electrical appliances based on their requirements. Not only that, the system also always come with an application or interface that enables user to control and monitor the devices connected remotely. Smart home security systems are often installed by professionals and the user get the benefit of dedicated consulting and engineering services [1]. The advantages of home security system such as hassle-free and

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consistent security have successfully piqued the market's interests.

There were various smart home security systems proposed by different researchers. This paper focused on reviewing different smart home security system that comprised of sensors and camera module in order to detect motion and notify user as well as aim to determine the challenges and prospect in this field of technology.

2. IoT Based Facial Recognition Door Access Control Home Security System Using Raspberry Pi

The paper in [4] introduced a facial recognition door access control home security system. The system adapted the Convolutional Neural Network (CNN) technique to identify authorized user when someone approached the doorstep. A web camera was set at the doorstep for real-time face recognition. Images captured by web camera will be sent to Raspberry Pi 3 to identify authorized person. When the person is recognized, the door will be automatically open. If the face is not recognized, the person may press the doorbell and notification will be sent to mobile phone of house owner. The house owner can use the Blynk Application to view the live stream video feed of the visitor. House owner can also control the door access through Blynk Application.

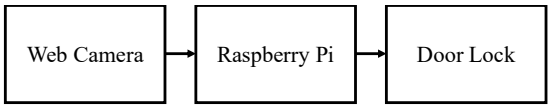

Fig 2. Architecture of system proposed in [4].

3. Home Security Monitoring System with IoT-based Raspberry Pi

Based on the design introduced in [5], an IoT-based home monitoring system was developed by integrating Raspberry Pi, Camera Module, PIR Sensor, Smoke Sensor and Temperature Sensor. The system is capable of monitoring the house and send notification through Telegram to the house owner. The house owner can send commands to obtain different sensor values from the system. When PIR sensor detects motion, the image of detected motion will be sent with notification via Telegram every 5 seconds.

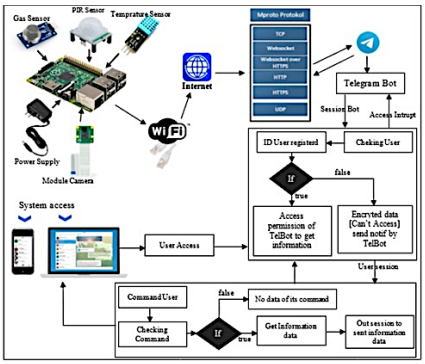

Fig 3. Home security monitoring system introduced in [5].

4. Internet of Things Based Indoor Smart Surveillance and Monitoring System using Arduino and Raspberry Pi

The authors in [6] proposed a security system using a simple robot. The robot was adapted with a motor driver circuit that helps to interface motor with controller and avoid back current from motor that may destroy the microcontroller. The robot was equipped with ultrasonic sensor to avoid obstacles in the house and PIR sensor to sense human movement. The robot will be moving around the house when user is not at home. When PIR sensor detects motion, the Arduino board triggers Raspberry Pi, turning on the web camera to capture images in the house and send them to user through cloud.

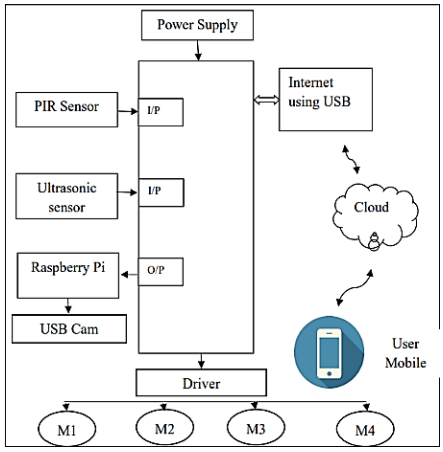

Fig 4. The block diagram of the smart surveillance and monitoring system [6].

5. Smart IoT Security System Using Motion Detection and Facial Recognition

In [7], the authors introduced a smart security system that integrated with facial recognition. The system used PIR sensor to detect motions from 5 meters to 7 meters. When PIR sensor detected motion, the signal sent from the sensor will trigger the Raspberry Pi to run code and allow the NoIR Pi Camera Module to capture images and record videos. A notification attached with the images and videos captured are then sent to user using the open-source Push Bullet API. The images and videos will also be stored in the Micro SDHC card in the Pi board. The proposed work used images captured from camera module and Local Binary Patterns Histogram (LBPH) algorithm to train the system for facial recognition. When there is unauthorized access, the user will be notified.

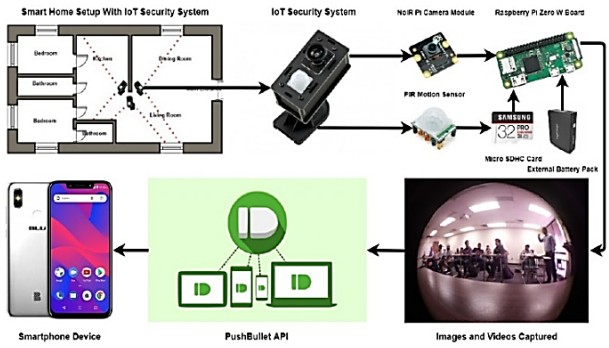

Fig 5. The architecture of smart security system proposed [7].

6. IOT BASED SMART HOME SECURITY AND AUTOMATION USING GOOGLE ASSISTANT

The paper proposed by authors in [8] integrated Google Assistant to the home security system. The system comprised of two modes, "Security ENABLE" mode and "Security DISABLE" mode. When the home owner is in the house, "Security DISABLE" mode will be triggered and all sensors will stay in sleep mode. "Security ENABLE" mode will be triggered when the owner leaves home and all sensors were activated. When there is Internet connection, any emergency message will be sent to the owner via Blynk Application over Wi-Fi. However, when there is no internet connectivity, the message will be sent through the GSM Module.

The Arduino NANO was connected with various sensors and Node MCU with inbuilt Wi-Fi module was used as medium between the user interface and feedbacks from the Arduino NANO. In this system, the Node MCU acted as server wile Arduino NANO acted as client. Node MCU will transfer all sensors' data received from the Arduino NANO to the Blynk Server. These sensors' data are then displayed in the Blynk Application. User will be alerted based on the sensors' readings. The system integrated IFTTT (If This Then That) module for verification of the Google Assistant command condition. Once the command given is verified, the command will be triggered to the Blynk Application to control the home appliances.

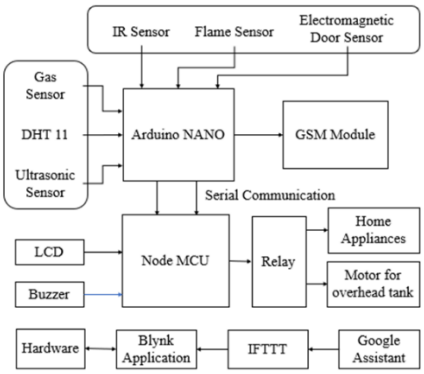

Fig 6. The architecture of method proposed [8].

7. IOT BASED LOAD AUTOMATION WITH REMOTE ACCESS SURVEILLANCE USING ESP 32 CAM AND ESP 8266 MODULE

The project in [9] focused to consolidate IoT in automation with control of garden watering pump and provide real time surveillance for the allocated areas. The system proposed consists of ESP8266, ESP32 CAM, Relay Module, Raspberry Pi and Soil Moisture Sensor.

User can control the loads connected to the system by giving command in Blynk Application. The Blynk Server will then update the ESP8266 status to switch the loads. The Moisture Sensor data was sent to the Blynk Server to update the current moisture gauge value displayed in Blynk Application. User will receive notification when the moisture content is low. For surveillance system, Live video feeds from ESP32-CAM can be accessed through live streaming URL from the Blynk Application.

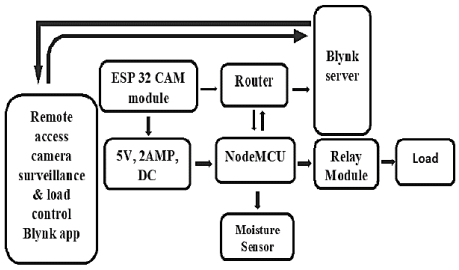

Fig 7. The block diagram of the smart surveillance security system [9].

8. SMART BUILDING: SMART SURVEILLANCE SECURITY SYSTEM

The paper in [10] focused on developing a smart building which sends cautions to the concerned individual by utilizing Internet in the event of any trespass and raises an alert alternatively. The components used in this system were PIR Sensor, CCTV, Raspberry Pi, Buzzer and Mobile Application.

The operation of the prototype begins with the identification of motion by PIR Sensor. When motion is detected, CCTV will capture an image of the motion. This image is then processed for facial recognition. If human face is detected, the image will be stored in cloud storage. Notification will be sent with the image of human detected by the Mobile Application.

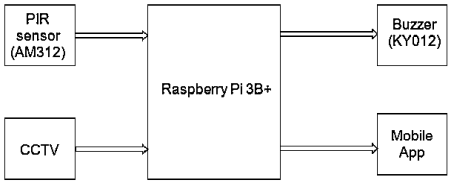

Fig 8. The smart security and home automation system proposed in [10].

9. DESIGN AND IMPLEMENTATION HOME SECURITY SYSTEM AND MONITORING BY USING WIRELESS SENSOR NETWORKS WSN/INTERNET OF THINGS IOT

The authors in [11] proposed a secure home system that is capable of sensing gas, humidity, temperature and motion. The system also provides an interactive interface to warn the house owner on any trespasses. The block diagram of the system is shown in Figure 8.

The Key Lock System comprised of Arduino, Keypad, LCD and Servo Motor. If the password entered was correct, Arduino will open the door using Servo Motor. If wrong password attempted for three times, Arduino will not open the door and SMS warning will be sent to user.

The RFID System used Arduino and RFID Card Scanner to check for authorized card. When authorized card is scanned, a green LED indicator lights up. If unauthorized card is scanned, red LED indicator lights up and SMS warning will be sent to user.

The sensors were connected to the Arduino. Arduino receives sensors feedbacks and show messages based on the

feedbacks in the serial monitor. If there is any abnormal value, a buzzer will be triggered. When the sensor values returned normal, the buzzer will be turned off.

The motion detection system comprised of two PIR sensors. The PIR sensor was installed at the left and right side. When motion is detected, Servo Motor moves the Camera to the right or left side based on the side that motion was detected. The Camera records the event and the recording will be saved in desktop of Raspberry Pi. The house owner can later access the recordings from Raspberry Pi.

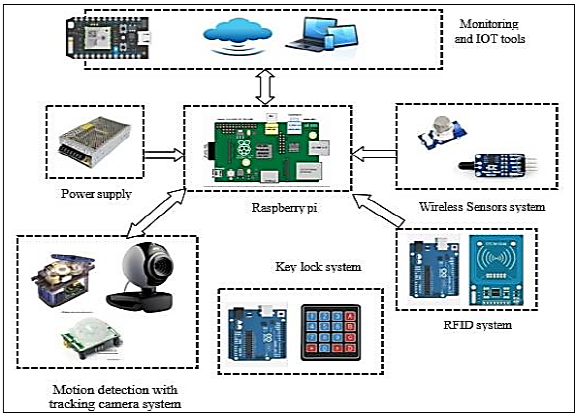

Fig 9. The block diagram of system proposed in [11].

10. Internet of Things-Based Intelligent Smart Home Control System

The paper in [12] introduced an intelligent home control and security system (iHOCS). The iHOCS comprised of six modules, the intelligent device module, the communication and gateway module, the management and decision module, the cloud computing module, the presentation module and the security module.

In the intelligent device module, the home appliances such as light bulbs, fans and sensors were integrated with a level of smartness to receive command and response respectively. Different sensors were included in this module such as motion sensor, gad sensor and temperature and humidity sensor. This module also consisted of a smart camera for capturing images of intruders.

The communication and gateway module is solely responsible for the interaction and communication between the home devices and sensors and the outside world. ESP8266 was used to provide Internet connectivity to the system for communication to all devices and home appliances.

The management and decision module is used to enhance the home security system. When PIR sensor sense motion, the image captured by camera will be processed using machine learning algorithm to differentiate between house occupants and intruders. This is to reduce the false alarm due to normal activity of house occupants around the home area. The module will notify user and save the image captured if there is intruder.

The cloud computing module functions as storage for data generated from sensors. The data stored can be used for home monitoring and analysis for future prediction. These data from sensors will also be displayed on the user's mobile phone.

The presentation and control module describes the user interface to control the home. User is able to view and monitor the sensor output from the mobile application and also control the desired device or appliances.

The system security module prevents unwanted access to the user platform. Authentication code will be sent to user's email when user wants to control and monitor the home. Without the correct authentication code, user will not be able to communicate with the home system.

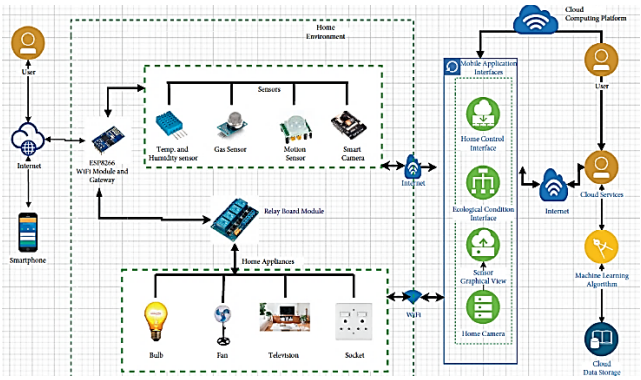

Fig 10. The block diagram of system proposed in [12].

11. Design and Implementation of a Smart Home System with Two Levels of Security Based on IoT Technology

The authors in [13] presented a smart home system that includes two main parts, the security system and the automation control system.

The security system comprised of PIR sensor and laser beam with Light Dependent Resistance (LDR). When PIR sensor sense motion, Arduino Nano will activate the alarm, Wi-Fi Camera and send logic "1" to the Node MCU. The Node MCU will display the alarm message on the GUI. When the intruder passed through the laser beam, Arduino Nano will also perform the actions above. The user can enter password using the keypad to enable or disable the system.

For the automation and control part, Arduino Nano receives feedbacks from various sensors and sends logic "0" or "1" to the Node MCU. The Node MCU is responsible to display the necessary messages on the GUI. The home owner can constantly monitor the home condition from the Android Application. The home owner can also control the servo motor from this application to remotely control the garage door.

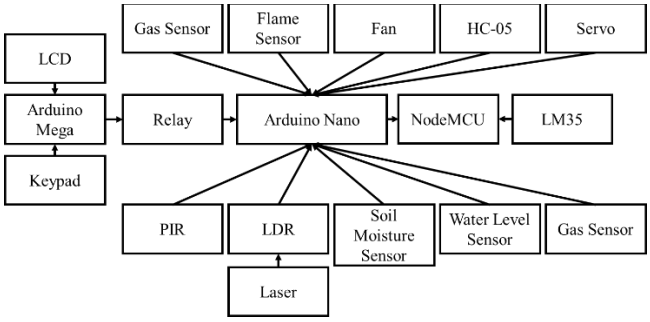

Fig 11. The block diagram of system proposed in [13].

12. Security Surveillance and Home Automation System using IoT

Paper in [14] implemented the functionality of wireless home automation ang home security. The system proposed comprised of two parts, home security and home automation.

The home security system includes the smart security camera module and the Android door lock. The smart security camera module comprised of Raspberry Pi and Pi camera. The camera can detect a face of person standing long time in front of the house by implementing face recognition technique with OpenCV. The image of the person will be sent to the home owner via email. As for the Android door lock, Raspberry Pi receives command from Android device to lock or unlock the door.

There are two parts in the home automation system, the rain sensing windows and automatic light on and off. The rain sensing windows integrated a rain sensor to determine if it is raining. If it is raining, the windows of the house will be automatically closed and the windows will be opened once the rain stops. IR sensor has been used to detect presence of people in the house. If there are people in the house, the LED will switch on. When the people leave the house, the LED will switch off.

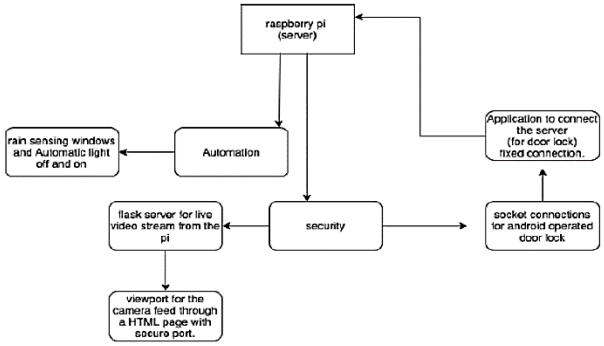

Fig 12. The architecture of system proposed in [14].

13. A Real-Time Controlled Closed Loop IoT Based Home Surveillance System for Android using Firebase

The paper in [15] presented a low-cost IoT based home security system that consists of four key components, the Wi-Fi module, the Motion Sensor, the Camera Module and the GSM Module.

The Wi-Fi module consists of Node MCU which acts as the communication hub for sending and receiving data between the modules. The Node MCU also checks the sensors' status. If there is any security concern, it sends signal to Firebase and this signal will be further interpreted into notification alert on the android application.

The motion sensor module used PIR sensor for motion detection. When motion is detected, the sensor sends signal to trigger buzzer and the Wi-Fi module for further processing.

The camera module used ESP32 CAM mounted on top of servo motor. User can control the servo motor from the android application to adjust the angle of camera. User can also control the camera to capture image. The images captured will be stored in the android device storage.

The GSM module consists of SIM900A and is connected with Arduino UNO. This module is mainly responsible for sending text messages to the home owner for security alert.

User can activate or deactivate the system using passcode or voice activation from the android application. When the system is active, alert notification will be sent to the house owner when PIR sensor detects intruder. The house owner can control the camera angle and capture images of the intruder from the android application and the images will be stored in the device's storage.

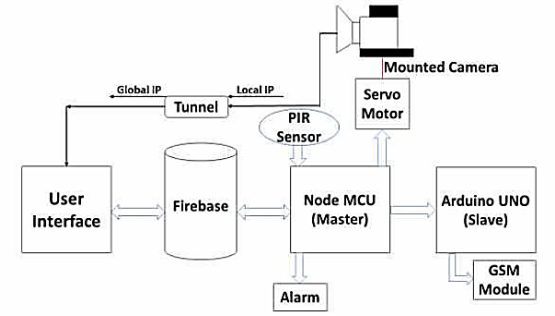

Fig 13. The architecture of system proposed in [15].

14. Surveillance Camera using IoT and Raspberry Pi

The paper in [16] proposed an IoT based security system integrated with PIR Sensor, Pi Camera and Raspberry Pi. When PIR sensor detects motion, the Pi Camera captures image of the motion detected. User can use the IP address of Raspberry Pi to view the images captured in mobile phone.

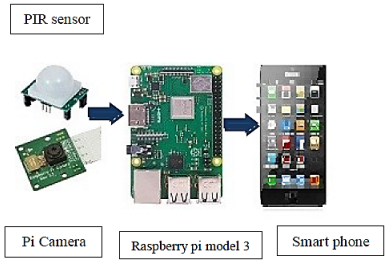

Fig 14. The architecture of system proposed in [16].

15. IoT Based Smart Security and Surveillance System

The system presented in [17] possessed of various security features such as remote camera surveillance, power failure detection, day and night modes intrusion detection with different ranges, alert through email and SMS and also face recognition for user authentication. The system can be divided into two subsystems, Perimeter Intrusion Detection System (PIDS) and Face Recognition System. The system comprised of Arduino Mega 2560 microcontroller, Ultrasonic Sensors, ESP8266 Node MCU Wi-Fi Module, LCD Display, Bolt Wi-Fi Module, Alarm and Zone Indicator.

PIDS is responsible for intrusion detection. It also provides early warning while the intruder has not yet entered to the secured area. PIDS has two modes, Day Mode and Night Mode. In Day Mode, there are 4 zone barriers, red, orange, yellow and green. The green zone indicates no person near the area of property. When a person walks into yellow or orange zone, they will be alerted. If the person ignored the alert and enter red zone, the owner of property will receive call, SMS or email alert and the alarm on-site will be triggered. The motion of person will be detected by a combination of multiple ultrasonic sensors. The intrusion event will be logged into the Blynk mobile application and this data can be accessed by the owner anytime. In Night Mode, there is only one barrier zone, which covers all four zone in Day Mode. There will be no early warning and the security features are as the red zone in Day Mode. PIDS also comprised of an ESP32-CAM mounted on a pan and tilt camera mount. The angle of camera can be controlled by owner remotely. The system can detect power failures using Bolt Wi-Fi Module. When the system loss power, a call alert will be sent to notify the owner on the situation. Thus, owner can take appropriate action to protect the house as the system is deactivated and not able to provide intrusion detection feature. The system is capable of remembering the last status of it before losing power and is resume functioning in the same mode by retrieving past status of Blynk server through Node MCU ESP8266 Module.

The Face Recognition System is provided through the ESP32-CAM. The system is trained with the image of owner and valid entrants. When a person approaches the property, ESP32-CAM captures an image of the person and compare the image to the valid entrants. If the person is valid entrant, he or she will have access to the property else the access will be restricted

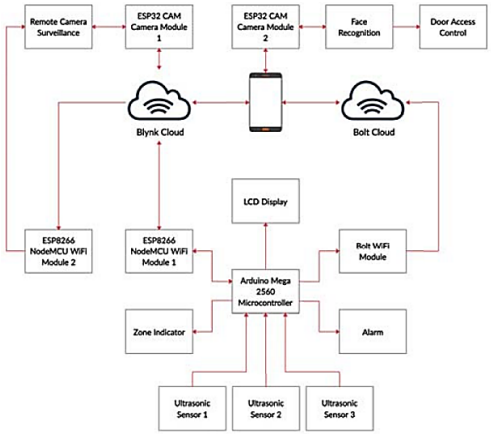

Fig 15. The architecture of system proposed in [17].

16. SMART SURVEILLANCE SYSTEM

Paper in [18] introduced a smart surveillance system that comprised of Raspberry Pi, PIR Sensor, Camera Module, mic and speaker. PIR detects motion when someone is at the doorstep. Raspberry Pi will then trigger the camera to capture images of intruder. Notification on the motion detection will be sent to admin. These images are then compared to the pre-saved images to determine if the person is allowed to access the door. If the images matched, Raspberry Pi send signal to the stepper motor to open the door else the stepper motor stays still.

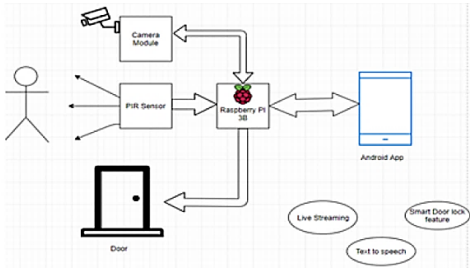

Fig 16. The architecture of system proposed in [18].

17. DESIGNING AN AUTONOMOUS TRIGGERING CONTROL SYSTEM VIA MOTION DETECTION FOR IOT BASED SMART HOME SURVEILLANCE CCTV CAMERA

Paper in [19] introduced a smart security system comprised of Ultrasonic Sensor, Raspberry Pi, Buzzer, Relay Module and CCTV Camera.

When ultrasonic sensor detects motion, Raspberry Pi triggers the buzzer which is connected to GPIO of Raspberry Pi and relay module. When relay module is triggered, current flows into the CCTV Camera and the camera is switched on. Cayenne Application is used to detect the changes in Raspberry Pi GPIO status. When the status changes, Cayenne Application send SMS notification to the user. User can open the Mi Home App to view the live image from the CCTV Camera. User can turn off the CCTV camera by switch off the relay module from Cayenne Application.

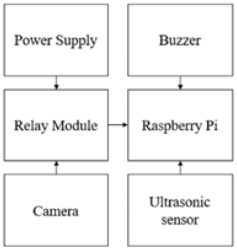

Fig 17. The architecture of system proposed in [19].

18. IOT BASED SECURITY SYSTEM USING RASPBERRY PI

Paper in [20] introduced a security system that views the entire floor for movement. When someone enters the house, the motion will be captured by switch sensors installed under the floor tiles. The Raspberry Pi will turn on the camera to capture the motion detected. The footage of image captured will be sent to the house owner

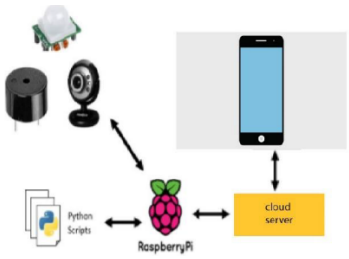

Fig 18. The architecture of system proposed in [20].

19. HOME SECURITY AGAINST HUMAN INTRUSION USING RASPBERRY PI

Paper in [21] introduced a security system designed as a smart mirror that is capable to accept touch and mobile commands. The system proposed consists of Raspberry Pi, Touch Enabled Screen, Camera, Power Bank and android mobile device. The system works in two modes, Normal Mode and Triggered Mode.

In normal mode, the smart mirror displays real time information such as the weather, latest news and calendar. The contents were dynamic content fetched using APIs and were displayed at the specified location on the smart mirror.

The smart mirror can switch to trigger mode by touch or mobile commands. In trigger mode, the smart mirror acts as a human intrusion detection system. When intruder is detected, the mirror captures a frontal photo of the person and send it to the home owner through SMS.

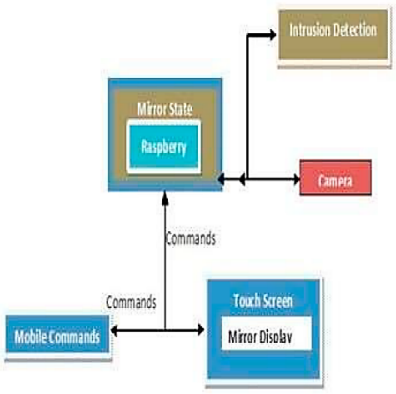

Fig 19. The architecture of system proposed in [21].

20. IOT BASED SMART SECURITY AND HOME AUTOMATION

Paper in [22] introduced a home security system that can provide information on current situation in the house while the house owner is away. The system introduced integrates NodeMCU-32S with Pi Camera, Door Sensor, Gas Sensor, Flame Sensor and Ultrasonic Sensor. The sensors send data to the Node MCU and the data is then sent to Blynk server after processing. The Blynk Server visualize the data received in form of graph. When ultrasonic sensor detects motion, image will be captured by the Pi Camera and notification will be sent to the house owner. The images captured will be stored in Node MCU so user can access to the images for finding intruder. The system also sends notification when there is abnormal condition such as high temperature, high volume of smoke and gas and door is opened forcefully. The data from the sensors are always updated to the Blynk Server for continuous monitoring of current home status.

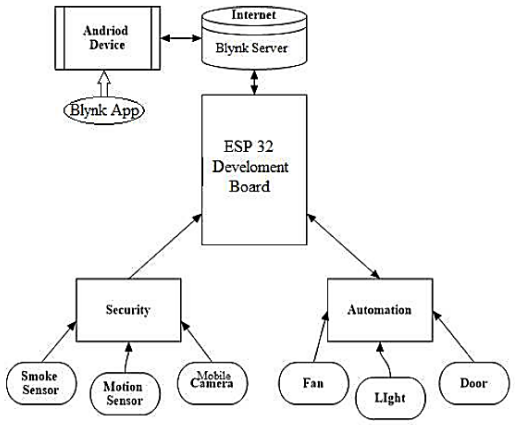

Fig 20. The architecture of system proposed in [22].

21. REAL-TIME SMART HOME SURVEILLANCE SYSTEM OF BASED ON RASPBERRY PI

Paper in [23] proposed a system that combines multiple sensors and devices to establish a safer home environment. The system is also user friendly to the elderly or the challenged people as it integrates a voice control module. The house owner can remotely control the devices at home by connecting the Raspberry Pi with VNC Viewer. Gas Sensor is integrated in the system to detect harmful gas. If the density of harmful gas exceeds a threshold, the house owner will be notified through LINE. The system used a Micro Bit Magnetic Sensor to detect the opening of door or window. If the sensor determines that the door or window is open, the house owner will be notified too. After receiving the alert notification, user can view the corresponding video screen captured by the camera from Raspberry Pi using VNC Viewer. The system is also capable of voice control. The virtual assistant can receive natural language instead of instructional sentences to control the system.

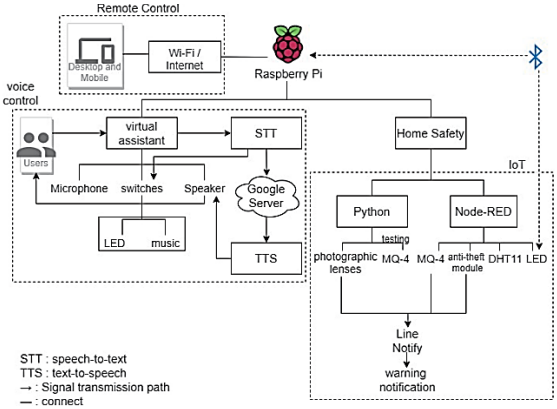

Fig 21. The architecture of system proposed in [23].

22. SMART HOME SECURITY SYSTEM

Paper in [24] introduced a smart home security system that can detect and capture details of intruder. The system captures the details of intruder and compare the captured image to the datasets in database. The face component features were then extracted from the image. If the image matches with data in database, the house owner will receive notification specifying

the name of intruder along with the image captured. If the image does not match, the house owner will receive notifications with the relevant information from database. After receiving the notification, if the house owner recognizes the intruder, he or she can save the image of that person in database. If the owner does not recognize the intruder, a final alert will be sent to the house owner device.

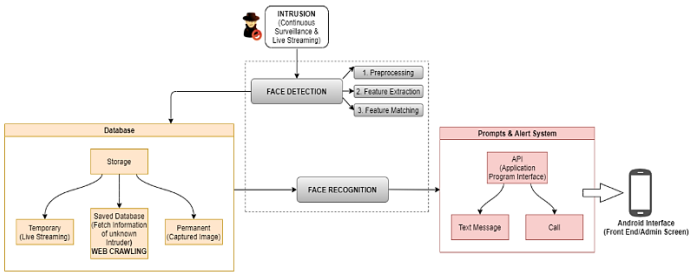

Fig 22. The architecture of system proposed in [24].

23. IoT Smart Home Assistant for Physically Challenged and Elderly People

The system introduced in [25] considered the necessity to monitor the surroundings of house and to control and monitor the home appliances remotely.

The system comprised of PIR sensor which detects motion and send signal to Raspberry Pi. Raspberry Pi will send a message with image of the motion detected to the user's email. User can access to the live stream video by connecting to the IP address of Raspberry Pi.

The system enables user to control the appliances form anywhere within the house. User can select devices to be controlled from the GUI. This eases the elderly or physically challenged people to control the home appliances. User can also choose to give voice command to control the home appliances.

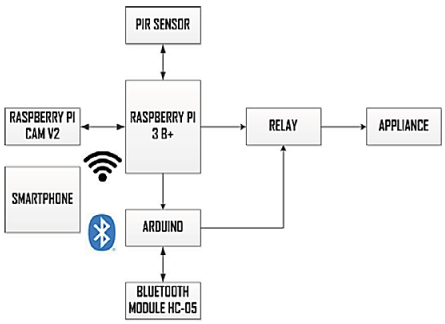

Fig 23. The architecture of system proposed in [25].

24. Smart Home Security with Dual Modes

Paper in [26] introduced a smart home security system comprised of PIR Sensor, Magnetic Sensor, Buzzer, Servo, ESP32-CAM and ESP32. The system presented works in two modes, Calibration Mode and Security Mode.

In calibration mode, the performance and condition of the system components are tested. The performance test includes checking the ESP32-CAM and buzzer functionality, adjust the servo position and inspect the sensor functionality and check the system reset button functionality.

Security mode includes two modes, Mode 1 and Mode 2. Mode 1 is used when the user is not at home while Mode 2 is used when user is in the house. In mode 1, the PIR sensor and magnetic sensor will actively detect motion and door opening. In Mode 2, only the magnetic sensor will be activated to detect invasive door opening. The home security system will be activated when sensors are triggered. The house condition can be monitored from a mobile application. The application interface remains green when the house is safe and turns red when the sensors are triggered or security system is triggered. When the security system is triggered, the ESP32-CAM will move, buzzer will be triggered and user will receive alert notification. After receiving the notification, user can use the mobile application for online streaming of image captured by ESP32-CAM.

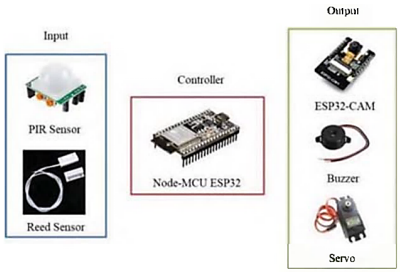

Fig 24. The architecture of system proposed in [26].

25. A Smart Home Security System In Low Computing IoT Environment

Paper in [27] introduced a face authenticated door lock system. The system is divided into five modules, the input unit, the processing unit, the enrolment module, the authentication module and the application module.

The input unit is responsible to obtain the facial image of intruder using camera and send the image to the processing unit. The processing unit which is Raspberry Pi in this case consists of the enrolment module, authentication module and application module. Enrolment module is used for feature extraction from the image received and storing of data collected in database. Authentication module is used to recognize and detect the input images. Application module includes the circuitry associated with the door lock system.

The system will capture image of intruder and obtain the facial feature. The properties of the face captured are the recognized by the system. Then, the image is further processed to check if the intruder is authenticated.

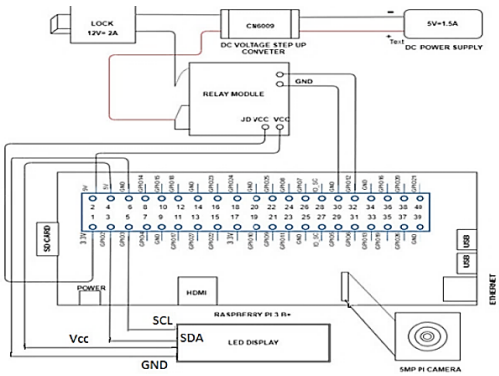

Fig 25. The architecture of system proposed in [27].

26. SECURITY MANAGEMENT IN SMART HOME ENVIRONMENT

Paper in [28] introduced a smart home environment that protects people from any kind of robbery, sabotage and crime.

Surveillance cameras are installed in the house areas and are connected to Raspberry Pi in order to capture movement and object. These data are then passed to the Fog Server for verifying if the object detected is harmful. If harmful object is detected, the user will receive alert notification. The user needs to validate with Cloud Server to log into the web-based interface to view the images captured.

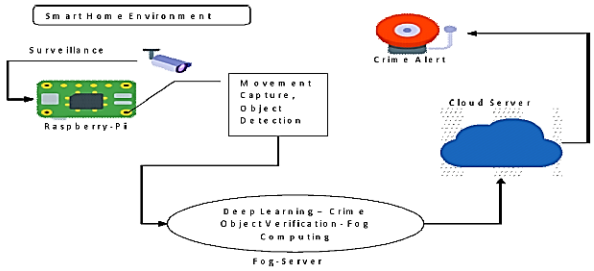

Fig 26. The architecture of system proposed in [28].

27. SMART SURVEILLANCE SYSTEM USING TENSOR FLOW

Paper in [29] provides a solution to home and business security concern by implementing object and motion detection using Raspberry Pi.

The system detects an object and classify the object using image processing tools by acquiring image from the real-time video. If any human movement is detected, the system sends alert notification to user through SMS.

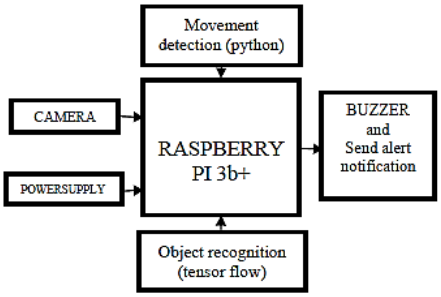

Fig 27. The architecture of system proposed in [29].

28. SURVEILLANCE MONITORING SYSTEM BASED ON INTERNET OF THINGS

Paper in [30] introduced a surveillance monitoring system comprised of two parts, the Local System and the User App.

The local system consists of Sensor Node, Camera Node and Gateway. The sensor node used PIR Sensor connected to Node MCU for motion detection. The camera node contains Raspberry Pi Camera Module that can capture the image of surroundings. The sensor node sends signal to gateway to capture image when movement detected. The Raspberry Pi receives signal from gateway and upload the image captured to server. Gateway acts as the access point to control the entire connected node in the system. It receives information from sensor node and sends information to camera node and web server.

The user app describes the user interface to access the system remotely. The web server integrated in the system uses Firebase real-time database service and it functions as storage for the images captured by the system. The Android Application allows user to control and monitor the system from mobile phone.

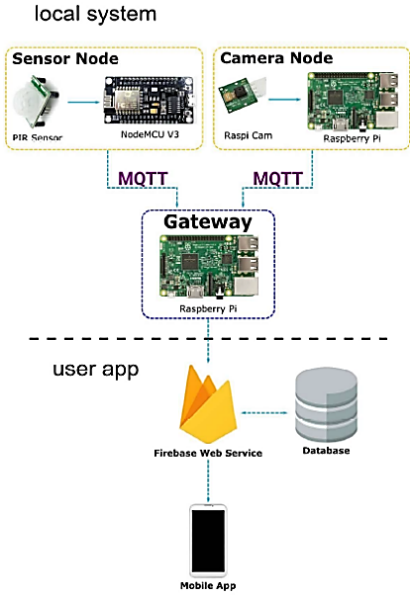

Fig 28. The architecture of system proposed in [30].

29. IP BASED SURVEILLANCE ROBOT USING IOT

Paper in [31] proposed an intelligent security robot that checks the presence of intruder.

The robot will move in the specified path at the site through the motor drivers. When PIR sensor or ultrasonic sensor detects human, it sends signal to Raspberry Pi. The Node MCU receives signal from Raspberry Pi and forward the signal to buzzer and GSM module. GSM module is responsible to send message to the user specifying if human or object is detected. Live stream footage from camera can be accessed from the mobile application.

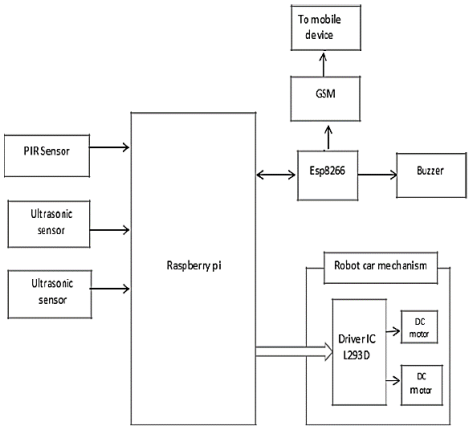

Fig 29. The architecture of system proposed in [31].

30. Implementation of Home Security Motion Detector using Raspberry Pi and PIR Sensor

Paper in [32] focused on delivering a system that detects motion and sends notification to user.

When PIR sensor detects motion, the Pi Camera records a video of 30 seconds. This video is sent to Raspberry Pi for conversion to MP4. After converting the video file format, Raspberry Pi sends the output to Botfather for notifying user through Telegram on the motion detection. User can enter different commands to activate or deactivate the system, retrieve the recordings and images captured from Raspberry Pi and check the system status.

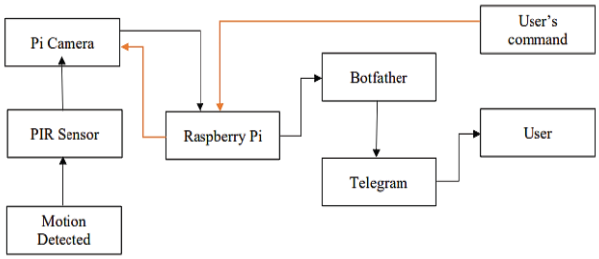

Fig 30. The architecture of system proposed in [32].

31. Design and Development of IoT based Smart Security System in Covid19 Situation

Paper in [33] proposed a smart security system. The system is able to detect visitor less than 5 feet from the doorstep using ultrasonic sensor. The system also used thermal camera to capture thermal image. The temperature of visitor can be obtained from thermal image processing. The data collected is uploaded to cloud using Node MCU. If the visitor is in the red zone, the owner will receive an alert notification. User can view the visitor information such as visit date and time and the visitor body temperature.

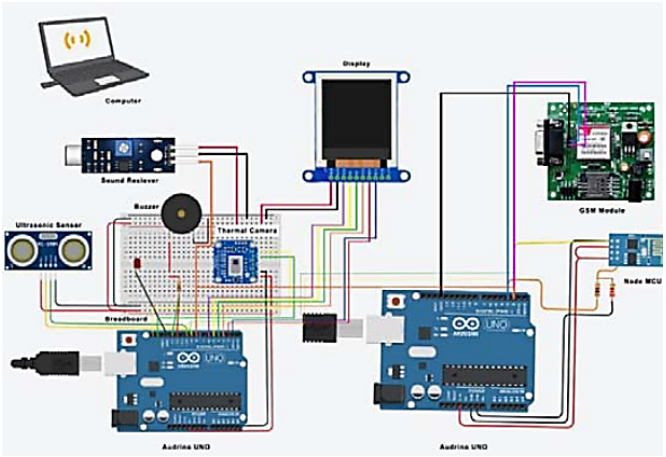

Fig 31. The architecture of system proposed in [33].

32. Challenges and Prospect

32.1 Challenges

Based on the related works studied, the challenges in establishing an IoT based smart home security system are as below:

a) *Connectivity*: IoT system required network connection. The effectivity of the system in monitoring and controlling home environment is highly dependable on the strength and speed of network. User will need to have stable network connection in the house for the system to receive request on time. Not only that, network connection on the user device that is used for control and monitoring purpose should have a strong network connection in order to receive feedback from the system installed in house as fast as possible. Weak connection may cause delay in the communication between devices which further leads to late response from the sensors or appliances in the system.

b) *Cost*: The system may be expensive depending on the user requirements. Most of the system introduced in the related works comprises of a microcontroller that acts as control unit to connect sensors and home electrical appliances. User may also need to purchase different components required such as sensors and camera. Besides, the cost of wiring for integration of sensors, camera and microcontroller will need to be considered as well. All of the above can add up to a high cost especially if user demand for a complex system.

c) Security: The security of the IoT system is also a major concern. The IoT system installed should not be easily accessible to others and a certain layer of security should be applied on the system to ensure the integrity and reliability of the system. This is to prevent any unwanted access that may possess threat to the house.

32.2 Prospect

Smart home security system mainly focuses on providing a reliable security service that is easy to manage and control from user side. In the future, technology such as artificial intelligence and machine learning can be integrated into the system to introduce more advance functions such as data analysis and decision making based on camera and sensors feedback. For example, machine learning can be applied to identify fire to enable water sprinkle. Facial recognition can be applied to recognize the user identity and automatically switch on the lights and fan when user reach the doorstep. Besides, voice recognition can also be integrated to offer voice control over the home appliances.

33. COMPARISON OF RELATED WORK

The systems discussed above are compared and listed in the table below.

Table 1. Comparison of related works

No.	System	Control unit	Camera	Intruder detection	Other sensors	Notification
1.	IoT based facial recognition door access control home security system using raspberry pi	• Raspberry Pi	Yes	Detection by face recognition	-	• Blynk Application
2.	Home security monitoring system with IoT-based Raspberry Pi	• Raspberry Pi	Yes	Detection by PIR Sensor	• Smoke Sensor • Temperature Sensor	• Telegram
3.	Internet of Things Based Indoor Smart Surveillance and Monitoring System using Arduino and Raspberry Pi	• Arduino • Raspberry Pi	Yes	Detection by PIR Sensor	• Ultrasonic Sensor	• Cloud
4.	Smart IoT Security System Using Motion Detection and Facial Recognition	• Raspberry Pi	Yes	Detection by PIR Sensor	-	• Push notification
5.	IoT Based Smart Home Security and Automation Using Google Assistant	• Arduino NANO • GSM Module • Node MCU	No	Detection by PIR Sensor	• Flame Sensor • Electro-magnetic Door Sensor • Gas Sensor • Ultrasonic Sensor • Temperature and Humidity Sensor	• Message
6.	IOT Based load Automation with Remote Access Surveillance Using ESP 32 CAM and ESP 8266 Module	• ESP8266	Yes	-	• Moisture Sensor	• Blynk Application
7.	Smart Building: Smart Surveillance Security System	• Raspberry Pi	Yes	Detection by PIR Sensor	-	• Mobile Application
8.	Design and implementation home security system and monitoring by using wireless sensor networks WSN/internet of things IOT	• Raspberry Pi • Arduino UNO	Yes	Detection by PIR Sensor	• Temperature and Humidity Sensor • Gas Sensor	• SMS
9.	Internet of things-based Intelligent Smart Home Control System	• ESP8266	Yes	Detection by PIR sensor	• Temperature and Humidity Sensor • Gas Sensor	• Mobile Application
10.	Design and implementation of a smart home system with two levels of security based on IOT Technology	• Arduino Nano • Node MCU • Arduino Mega	No	Detection by PIR sensor and laser beam with LDR	• Gas Sensor • Flame Sensor • Soil Moisture Sensor • Water Level Sensor	• Android Application
11.	Security surveillance and home automation system using IOT	• Raspberry Pi	Yes	Detection by face recognition	• Rain Sensor	• Email
12.	A real-time controlled closed loop IOT based home surveillance system for Android using Firebase	• Node MCU • Arduino UNO	Yes	Detection by PIR sensor	-	• SMS
13.	Surveillance camera using IOT and Raspberry Pi	• Raspberry Pi	Yes	Detection by PIR sensor	-	-
14.	IoT Based Smart Security and Surveillance System	• Arduino Mega 2560 Microcontroller	Yes	Detection by ultrasonic sensor	-	• Call • SMS • Email

15.	Smart Surveillance System	• Raspberry Pi	Yes	Detection by PIR sensor	-	• Notification
16.	Designing an Autonomous Triggering Control System via Motion Detection for IoT Based Smart Home Surveillance CCTV Camera	• Raspberry Pi	Yes	Detection by ultrasonic sensor	-	• SMS
17.	IOT based security system using Raspberry Pi	• Raspberry Pi	Yes	Detection by switch sensor	-	• Notification
18.	Home security against human intrusion using Raspberry Pi	• Raspberry Pi	Yes	Detection by face recognition	-	• SMS
19.	IoT Based Smart Security and Home Automation	• NodeMCU-32S	Yes	Detection by ultrasonic sensor	• Gas Sensor • Door Sensor • Flame Sensor	• Blynk Application
20.	Real-time Smart Home Surveillance System of based on Raspberry Pi	• Raspberry Pi	Yes	-	• Gas Sensor • Micro Bit Magnetic Sensor	• LINE
21.	Smart Home Security System	• Orange Pi • GSM Module	Yes	Detection by face recognition	-	• Android interface
22.	IoT Smart Home Assistant for Physically Challenged and Elderly People	• Raspberry Pi	Yes	Detection by PIR sensor	-	• Email
23.	Smart Home Security with Dual Modes	• ESP32	Yes	Detection by PIR sensor	• Reed sensor	• Notification
24.	A smart home security system in low computing IOT environment	• Raspberry Pi	Yes	Detection by face recognition	-	-
25.	Security Management in smart home environment	• Raspberry Pi	Yes	Detection by image processing	-	• Notification
26.	Smart Surveillance System Using Tensor Flow	• Raspberry Pi	Yes	Detection by image processing	-	• SMS
27.	Surveillance Monitoring System based on Internet of Things	• Raspberry Pi • Node MCU	Yes	Detection by PIR sensor	-	-
28.	IP Based Surveillance Robot Using IOT	• Raspberry Pi • Node MCU	Yes	Detection by PIR sensor and ultrasonic sensor	-	• Notification
29.	Implementation of Home Security Motion Detector using Raspberry Pi and PIR Sensor	• Raspberry Pi	Yes	Detection by PIR sensor	-	• Telegram
30.	Design and development of IOT based smart security system in covid19 situation	• Node MCU • Arduino UNO	Yes	Detection by ultrasonic sensor	-	• Notification

34. CONCLUSION

In a nutshell, IoT is a useful tool to connect various devices on a network that allow user to manage, monitor and control all devices at once to be paired with home-based surveillance and control system. IoT can be utilized in building a smart home security system that can monitor the house environment and send feedback to user. IoT is also easy to be integrated with other advance technology such as machine learning and artificial intelligence to introduce more functions and increase the standard of living.

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REFERENCES

[1] "Home Security Systems Market by Home Type (Independent Homes, Apartments), Security (Professionally Installed & Monitored, Do-It-Yourself), Systems (Access Control Systems), Services (Security System Integration Services), Region (2022-2027)," Markets and Markets, May 2022.

[2] W. Ejaz, A. Anpalagan, M. A. Imran, M. Jo, M. Naeem, S. B. Qaisar, and W. Wang, "Internet of things (IOT) in 5G Wireless Communications," IEEE Access, vol. 4, pp. 10310–10314, 2016.

[3] K. K. Patel and S. M. Patel, "Internet of Things-IOT : Definition , Characteristics , Architecture , Enabling Technologies , Application & Future Challenges," International Journal of Engineering Science and Computing (IJESC), vol. 6, no.5, pp.6122-6131, 2016.

[4] S. A. Radzi, M. K. M. Alif, Y. N. Athirah, A. S. Jaafar, A. H. Norihan, and M. S. Saleha, "IOT based facial recognition door access control home security system using Raspberry Pi," International Journal of Power Electronics and Drive Systems (IJPEDS), vol. 11, no. 1, p. 417, 2020.

[5] I. G. Desnanjaya and I. N. Arsana, "Home Security Monitoring System with IOT-based Raspberry Pi," Indonesian Journal of Electrical Engineering and Computer Science, vol. 22, no. 3, p. 1295, 2021.

[6] N. C. Sendhilkumar, C. Malarvizhi, M. Anand, and K. Periyarselvam, "Internet of things based indoor smart surveillance and monitoring system using Arduino and Raspberry Pi," Journal of Physics: Conference Series, vol. 1964, no. 6, p. 062083, 2021.

[7] A. K. M. J. Majumder and J. A. Izaguirre, "A smart IOT security system for smart-home using motion detection and facial recognition," 2020 IEEE 44th Annual Computers, Software, and Applications Conference (COMPSAC), 2020.

[8] E. Shirisha, K. V. Kumar, and G. Swarnalatha, "IOT based home security and automation using Google assistant," Turkish Journal of Computer and Mathematics Education (TURCOMAT), vol. 12, no. 6, pp. 117–122, 2021.

[9] A. Shukla and R. Diwan, "IOT Based load Automation with Remote Access Surveillance Using ESP 32 CAMand ESP 8266 Module," Annals of R.S.C.B., vol.25, pp. 6904-6914, 2021.

[10] Y. J. Tan, K. Praset, M. A. S. Hasnan, N. Zulkefle, R. Ngadiran, and N. F. Kahar, "Smart Building: Smart Surveillance Security System," Proceedings of Malaysian Technical Universities Conference on Engineering and Technology (MUCET), 2021.

[11] H. H. Qasim, A. E. Hamza, H. H. Ibrahim, H. A. Saeed, and M. I. Hamzah, "Design and implementation home security system and monitoring by using wireless sensor networks WSN/internet of things IOT," International Journal of Electrical and Computer Engineering (IJECE), vol. 10, no. 3, p. 2617, 2020.

[12] O. Taiwo and A. E. Ezugwu, "Internet of things-based Intelligent Smart Home Control System," Security and Communication Networks, vol. 2021, pp. 1–17, 2021.

[13] M. Murad, O. Bayat, and H. M. Marhoon, "Design and implementation of a smart home system with two levels of security based on IOT Technology," Indonesian Journal of Electrical Engineering and Computer Science, vol. 21, no. 1, p. 546, 2021.

[14] A. Sanjay, M. Vijarania, and V. Jaglan, "Security surveillance and home automation system using IOT," EAI Endorsed Transactions on Smart Cities, p. 165963, 2020.

[15] T. Ahmed, A. T. Bin Nuruddin, A. B. Latif, S. S. Arnob, and R. Rahman, "A real-time controlled closed loop IOT based home surveillance system for Android using Firebase," 2020 6th International Conference on Control, Automation and Robotics (ICCAR), 2020.

[16] B. N. Rao and R. Sudheer, "Surveillance camera using IOT and Raspberry Pi," 2020 Second International Conference on Inventive Research in Computing Applications (ICIRCA), 2020.

[17] G. Lulla, A. Kumar, G. Pole, and G. Deshmukh, "IOT based Smart Security and Surveillance System," 2021 International Conference on Emerging Smart Computing and Informatics (ESCI), 2021.

[18] S. K. Advirkar, P. V. Bhatkar, N. S. Katke, and D. Ghosal, "Smart Surveillance System," International Journal of Research in Engineering, Science and Management (IJERSM), vol. 3, no. 3, pp. 70-72, 2020.

[19] S. Ganesan, Y. Y. Than, P. Ravi, and P. L. Chong, "Designing an Autonomous Triggering Control System via Motion Detection for IoT Based Smart Home Surveillance CCTV Camera," 2022.

[20] N. Venugopal, C. E. P. Kumar, V. G. Goutham Prashanth, E. Manoharan , and K. Kesavamurthy, "IOT based security system using Raspberry Pi," International Journal of Engineering Research and Technology (IJERT), vol. 9, no. 02, 2020.

[21] R. A. Nadaf, S. M. Hatturea, V. M. Bonala, and S. P. Naikb, "Home security against human intrusion using Raspberry Pi," Procedia Computer Science, vol. 167, pp. 1811–1820, 2020.

[22] D. Jotawar, K. Karoli, M. Biradar, and N. Pyruth, "IoT Based Smart Security and Home Automation," International Research Journal of Engineering and Technology (IRJET), vol. 7, no. 8, pp. 2846–2850, 2020.

[23] Y.-C. Lee and C.-M. Lee, "Real-time Smart Home Surveillance System of based on Raspberry Pi," 2020 IEEE Eurasia Conference on IOT, Communication and Engineering (ECICE), 2020.

[24] F. Phaltanwala, S. Banawadikar, S. Burse, and K. Bhutada, "Smart Home Security System," International Research Journal of Engineering and Technology (IRJET), vol. 7, no. 4, pp. 6444–6447, 2020.

[25] S. K. Sooraj, E. Sundaravel, B. Shreesh and K. Sireesha, "IoT Smart Home Assistant for Physically Challenged and Elderly People," 2020 International Conference on Smart Electronics and Communication (ICOSEC), pp. 809-814, 2020.

[26] M. N. M. Razali, N. A. Abdul-Kadir and J. Kasim, "Smart Home Security with Dual Modes," 2020 IEEE Student Conference on Research and Development (SCOReD), pp. 453-458, 2020.

[27] J. Paul, R. Subhra Bhowmick, B. Das, and B. K. Sikdar, "A smart home security system in low computing IOT environment," 2020 IEEE 17th India Council International Conference (INDICON), 2020.

[28] L. M. Gladence, V. M. Anu, S. Revathy, and P. Jeyanthi, "Security Management in smart home environment," Soft Computing, 2021.

[29] B. V. Chetan, P. K. Bharath, S. A. Akarsh, M. Vernerkar, and B. K. N. Swamy, "Smart Surveillance System Using Tensor Flow," International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering (IJIREEICE), vol. 9, no. 7, pp. 96–99, 2021.

[30] M. U. Harun Al Rasyid, F. Astika Saputra and A. Kurniawan, "Surveillance Monitoring System based on Internet of Things," 2020 International Electronics Symposium (IES), pp. 588-593, 2020.

[31] M. Sunitha, P. V. S. S. Datta Vinay, V. S. N. Lokesh and B. D. Kumar, "IP Based Surveillance Robot Using IOT," 2020 Fourth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), pp. 337-342, 2020.

[32] A. H. Azhar, M. F. I. Othman, N. Bahaman, M. Z. Mas'ud, and Z. Sa'aya, "Implementation of Home Security Motion Detector using Raspberry Pi and PIR Sensor," Journal of Advanced Computing Technology and Application, vol. 3, no.2, pp. 41-49, 2021.

[33] S. Das, A. Dhar, B. Pal, P. Biswas, P. K. Gayen, and S. Majumder, "Design and development of IOT based smart security system in covid19 situation," Journal of Physics: Conference Series, vol. 1797, no. 1, p. 012048, 2021.