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An Approach For Cost Effective Security System Using Wireless Sensor Network

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Abstract- Wireless Sensor Networks are used most frequently these days and they have been proved as the most promising in high security areas. In this study, the sensor nodes communicate using Wireless Network and are used to create a security system which provides the user with the notification of any mishap that may occur in any organization. This system incorporates camera, gas sensor and temperature sensor nodes which provide security in every respect and the data is transmitted from sensor to base station using Wireless Sensor Networks. Thecomponents used in this proposed system use very less power, are low-cost and easy implementable. Moreover, the network is highly secured with flash encryption system so that data sent among nodes is not tampered easily.

Keywords - Wireless Sensor Network, Sensors, and Camera based security, Security, Low cost, Low energy, Flash Encryption System.

I. INTRODUCTION

As the crimes are increasing in a very frequent way, there is an urge to provide a security system to ensure safe and burglary free environment. Hence, we need a security system which can monitor the environment around us all the time. There are many applications in the market which provide security inside and outside the premises. Some of them are CCTV, photoelectric detectors, microwave detectors and many more. However, the systems available around are either too expensive for a common user or consumes more power than required which leads to costly set up and also memory space required is more which again adds to the cost.

A possible solution to curb this kind of issues is to use sensors which are cheap yet effective and they communicate with each other using Wireless Sensor Network[1], as these sensors are capable of detecting every abnormal situation immediately and they send the output instantaneously to the base station. This output can be used for further signal processing or activates other devices like alarm systems, lighting systems, recording systems, and similar devices. This could possibly save the power consumption to large extent as the components used inside are activated only when the intruders come in the proximity or range of the sensor.[2]. Therefore a sensor-based security system consisting of the PIR sensor, a lighting system (LEDs), a smoke detection sensor, and a recording system (OV7670 camera and the software for saving the video) can mitigate the above-stated problems to some extent. The sensors have the capability to detect the presence of intruders and gas leakage as well.

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Wireless Sensor Network is the backbone of this system design, as all the sensor nodes and their respective sub-station and base station are connected to each other via Wireless Network. This technique reduces the required network bandwidth and also gives alerts to the server, which reduces human efforts[1]. The required image processing techniques and algorithms are optimized to be suitable for the small memory and computation power of WSN nodes.

The sensors have their own memory, processor and can deploy themselves without any human interference if they are programmed accordingly. Application of this system is widely in houses, industries, offices, high alert areas, military[3], hospitals, and so on, wherever you need high security this system stands best[4]. Some security scenarios where this system acts best are as follows:

- Areas where you need hidden security applications like hidden cameras forspying[5].
- Gas leakage detection sensor will help in areas like gas manufacturer industry, home kitchen, other industries using gas forproduction[6].
- Smoke detection act as highly beneficial in areas like industries dealing with gasoline, oil, homes, offices,etc.[6][7].
- The cameras have storage and auto-capture system, which will capture the image of the intruder and store image in storage automatically without any humanguidance.
- The security algorithm used in the network is flash encryption. It is embedded in the device ESP-32 which is used with the sensor.

II. LITERATURE REVIEW

Chandan et al.[6]Considered the case of forest fire and how early detection of it can save the forest from heavy damage. A detailed study about forest fire is done like when fire catches up then which kind of gas is emitted and it was noted that gases like methane, carbon monoxide, carbon dioxide, and smoke are emitted. So, the author has used sensors like SHT15, also when the temperature increases rapidly then to measure it sensors like DHT111 and HYT221 are used. The user has been provided with a GUI which is made on Python, and it displays the results recorded by sensors, and in case the amount of gas increases the limit it alerts the user by a buzzer sound.

NiharRanjan Roy et al.[2]mentioned the ways by which we can save energy by setting the base-station in the right position and shape of the sensing field. The major position includes center, boundary, outside and corner of the sensing field. Test. A test was performed by the researchers in which they concluded that the throughput is more when the base station is placed in the center of the sensing field. The simulation was used to make it easy to understand, the simulation was done using LEACH protocol and on MATLAB.

Ema Teixeira et al.[8]discussed about how energy can be consumed in Smart Green Homes. He proposed a protocol named FTT-WSN. This protocol collects data in relevance to SGH but in a different manner. As there are many sensors that don‘t need high dynamics, they can operate only energy and some sensors need more energy, so to distribute energy accordingly is one of the features of this FTT protocol. This Flexible Time-Triggered (FTT) Protocol supports time and event-triggered communication. This protocol follows a master-slave cooperation model.

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As WSN comprise a group of nodes working together to accomplish a desired result by the different nodes. These nodes are efficient to convert physical parameters (temperature, pressure, humidity etc.) into digital form. WSN faces many problem associates with node deployment, reliability, energy consumption, fault tolerance etc. AnuragSaini et al.[9]has introduced energy efficient protocols to improve energy consumption in WSN. Instead of using any physical medium for transmission of information, the information is sent to the sink or base station. All node gathers information in the cluster. The protocol introduced by the author is more energy efficient as compare to LEACH Protocol for dynamic approach and manage the traffic from coming from different nodes.

In WSN there is high amount of data is transmitted from every node. It is difficult to store and process these data in sink. WSNs have serious shortages in order of data reliability and less communication capabilities. To overcome this problem big data systems are introduced. All the functions like data collection, storage, processing, analysis and visualization to be followed. Thus, Beom-Su Kim et al.[10]has made this paper to explain the concept of WSN for Big Data.

Making houses of more inclusive, safer, resilient and sustainable. Gas leakage and Fire is common threat in every house which can be main factor of loss of life and property. To solve this problemAastha Singh et al.[11]has designed this paper using MQ 2 module which is useful for gas leakage detection of gases such asLPG, CH4 (methane), H2, CO (Carbon Monoxide), Smoke orAlcohol,.which is connected with Arduino Uno for monitoring the responses and warning about the danger using buzzer. There are many different ways to send warning like SMS, E-mail notification and SOS call.

NehaBhadwal et sl.[3]have referred the situation of the border surveillance system[3] used for keeping eye on the borders. Before, this was done manually, due to which a lot of man power was needed. Thus, there was the need for designing an automated border surveillance system[3] which will be active for 24/7. This system will save the resources as well as will give more accurate result. The system is an Intrusion Detection System (IDS) for the border that uses the Wireless Sensor Network (WSN) technology. The infrared (IR) sensors installed on the border fence[3] sends signal to the microcontrollers when an intruder is detected.

Moses Oluwafemi ONIBONOJE[12] wants the college students to understand the main concept of Wireless Sensor Networks (WSN) through paper. In this paper, the author took an example of the safety of road users at a railway level-crossing. There are three-level detection rack consisted in this system design, in which the train that is approaching the junction is detected and the signal is wirelessly transmitted to indicate the level-crossing road users. The sensing portion compromises of the sensors detecting the vehicles that are present at the incident, then they send the signal to the microcontrollers which then turns on the buzzers.

III. WIRELESS SENSOR NETWORK

WSN consists of several sensor nodes connected with each other in a particular topology or randomly.Thesensornodescommunicatewitheachotherwirelessly as shown in Figure 1.ThenetworkisAd-hoc,which means the network doesn't have a fixed infrastructure. Wireless Network is used for information dissemination and gathering

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between nodes. Wireless Sensor Nodes have limited bandwidth. So, nodes need to send data to the base station as soon as they collectit.

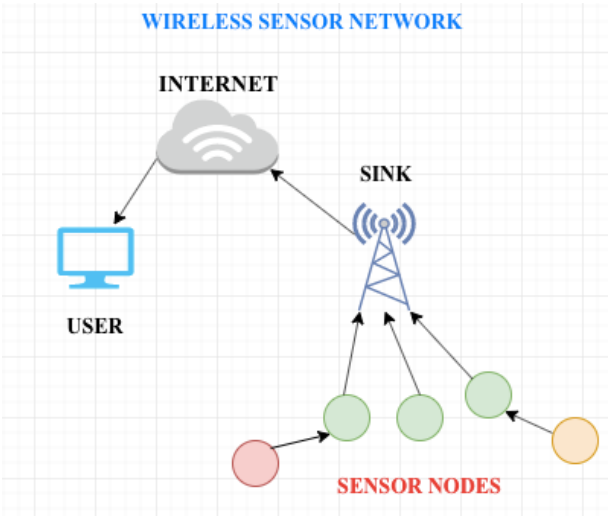

Figure 1 Wireless Sensor Network

Wireless Sensor Network has immense use in security purposes as the information sent over this network is fast and can be secured using various protocols.

Base Station or Sink act as a channel between sensors and user. It collects all data from various sensor nodes and sent it over Wireless Network to the user. The data between sensors and base station can be shared by multi-hop or directly. Sensor nodes communicate with each other through radio waves.

Sensor Nodes can deploy by themselves or by human interference. Nodes have their own memory where data is saved when it is collected from physical world. They have limited energy supply and can get damaged physically. So, they need to be carefully monitored periodically[1].

IV. NODES USED IN THE SYSTEM

The security system used in this paper consists of three nodes which in combination provides a cost-effective solution to the security problems in WSN. All the nodes are crucial and have different roles to play in this system as shown in Figure 2. The main purpose of these nodes is discussed below.

A. NODE 1

MOTION SENSOR NODE

This node gets activated whenever it detects an intruder in the given range. It has the capability to detect the intruder in every 5-sec interval. Else it remains in sleep mode. This event-driven action will consume energy[8]. Further, the sensor will send signals to the camera node.

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CAMERA NODE

This node will capture the image as soon as it receives a signal from a motion sensor. It will capture the image of the intruder detected and sent it using the wireless network to the base station. Further, the base station will send data to the user[5][13].

B. NODE 2

SMOKE DETECTION SENSOR

This node will detect the nature of smoke or gas in the area where it is placed[7]. The type of gas that can be harmful is methane, LPG, butane and any kind of acidic smoke[11]. The data collected about the kind of gas is further sent to the base station and further, it will be forwarded to the user. If the quantity of gas will be high, then the alert system will be triggered.

C. NODE 3

TEMPERATURE DETECTION SENSOR

This sensor node will detect the temperature of the surrounding[6]. In case there is a rapid increase in temperature, it will generate the alert.
The recorded temperature will be sent to the base station wirelessly and further, to the user.

Users can store the data recorded in the database or watch live. Both things can be achieved with this proposed system.

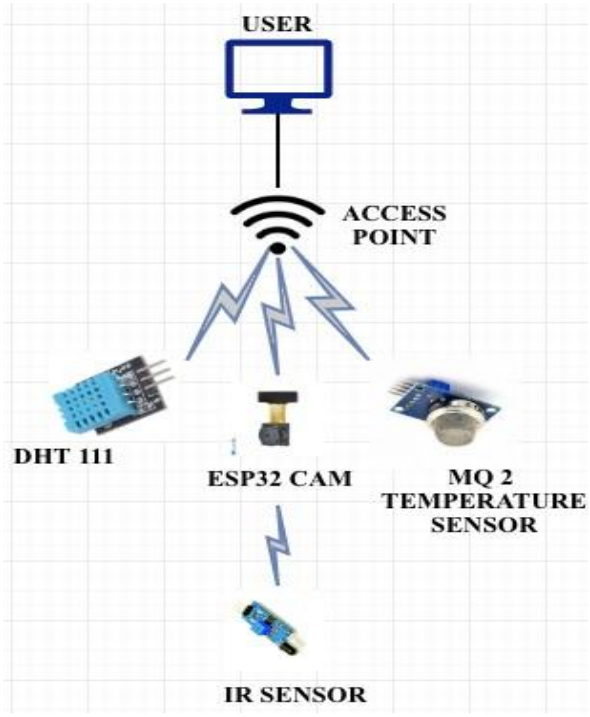

Figure2 Node Diagram of this system

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IV. HARDWARE

A. IR SENSOR

It is an electronic device which works by sensing the intruder in its range. The infrared sensor detects the heat generated by object and can also detect the motion performed by anybody[12].
It can measure only infrared radiations. It has a light sensor which detects the selected light range in Infra-Red spectrum. There is one LED also which produces the light of same wavelength so that you can see the intensity of received light as shown in Figure 3. It has much accurate readings then PIR sensor. Applications of IR sensors are Radiation Thermometers, Flame Monitors, Moisture Analyzers, IR Imaging Devices and Gas Analyzers. IR light is not easily detected as it its wavelength is 700nm – 1mm. angle covered by IR sensor is 20-60 degree approximately.

Figure 3 IR Senor

B. ESP-32 MODULE AND CAM

It has two modules, one contains a development board and the other is a small camera that is inserted in the slot given on the module. The camera captures the image and then it is processed by the ESP-32 module[14]. It is a wi-fi module and consumes very low power. Images can be uploaded via wi-fi by using this module as shown in Figure 4. To make ESP-32 work we need FTDI program writer, it will help in implementation. ESP-32 is the smallest camera module can operate at least 5 system with footprint of 40 * 27 mm and 802.11b/g/n Wi-Fi BT SoC module also support Wi-Fi upload. This device is working reliably with an operating temperature range -40°C to +125°C.

Flash Encryption- It is inbuilt in ESP32 and ensures that application that is stored in flash of ESP32 remains encrypted[15]. It has AES key, which is stored in eFUSE and eFUSE decrypt the AES. The key generated is locked inside eFUSE, so only hardware can decrypt it, to access flash.

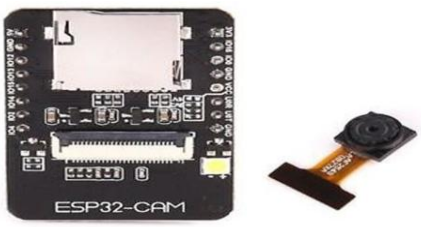

Figure 4 ESP- 32 module and its Camera

C. ARDUINO

Arduino Uno board is used in this prototype. It has its own microcontroller which is based on ATmega328as shown in Figure 5. Power can be supplied using a USB cable. The Arduino software is used for programming this board according to your needs. Simply write the program in microcontroller using ArduinoSoftware[11]. Devices have operating voltage of 5 voltage and input

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voltage of 7 to 20 volts.

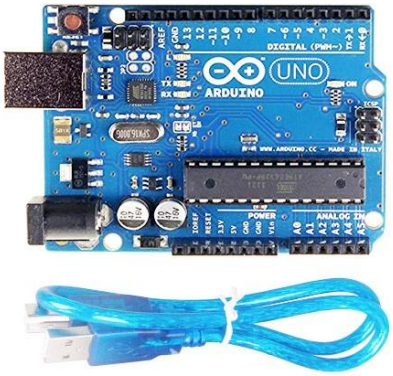

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Figure 5 Arduino Uno Board

D. DHT 111 TEMPERATURESENSOR

This sensor includes one NTC temperature measurement component. It also has a microcontroller which decides whether the temperature is above danger point or below it as shown in Figure 6. Operating Voltage is 3.5V to 5.5V and Temperature range is 0°C to 50°C. Applications are Measures temperature and Humidity, Local Weather Station, Automatic climate control and Environment monitoring[6].

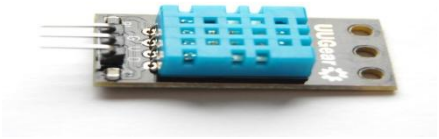

Figure 6 DHT 111 Temperature Sensor

E. MQ 2 SMOKE DETECTIONSENSOR-

The sensor as shown in Figure 7 contains SnO2 which has lower conductivity in clean air but this conductivity increases when gas keeps rising in the surrounding. This way we get an indication of high dangerous gas. MQ 2 is metal oxide semiconductor type sensor[7]. Concentration of the gases is measured by using voltage divider network in the sensor which can detect gases in the sensor which can detect in the concentration range of 200-10000ppm. It is low cost and consumes low energy for processing. This module is used to detect gases such as LPG, CH4 (methane), H2, CO (Carbon Monoxide), Smoke orAlcohol.[6]. Main features of MQ 2 sensor is wide detecting scope, stable and long lifetime, fast response and high sensitivity[11].

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Figure 7 MQ 2 Smoke Detection Sensor

F. BUZZER

This piezo buzzer is used as an alert system and makes noise when it receives signal from various sensors as shown in Figure 8. It makes a noise of sufficient decibel. It is also a low cost and consumes negligible energy.

Figure 8Piezo Buzzer

V. IMPLEMENTATION

Flowchart of the System

The working of IR sensor in the security system is shown in Figure 9. As the flowchart depicts, first the IR sensor will detect motion. It sends signal to camera and camera gets activated. It will capture image of intruder. Meanwhile the buzzer and LED get ON as an alert function. Now the camera will function in two ways, first live stream of data on web server provided to the user. Second, it will store the visuals in the SD card[10]. After the event has happened and when sensor is detecting no motion the node will go to sleep mode.

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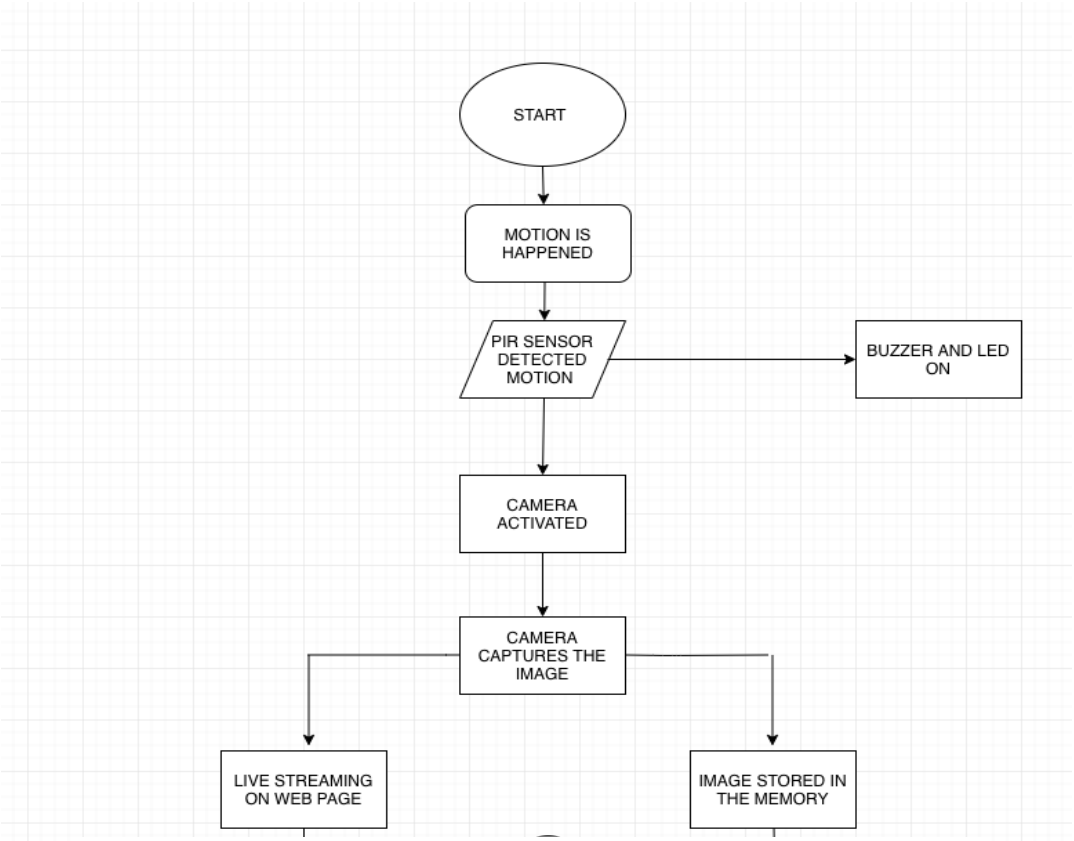

Figure 9 Flowchart of Camera Node

The working of Smoke detection sensor node explained through flow chart as shown in Figure 10

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When smoke detection sensor will detect any gas, it will get active. The responses will get compared with critical point provided by the user[6]. If the recorded value is greater than the set value, buzzer and LED will on during the incident. Else the system will work normally. After the event is done, sensor will go to sleep mode for energy conservation.

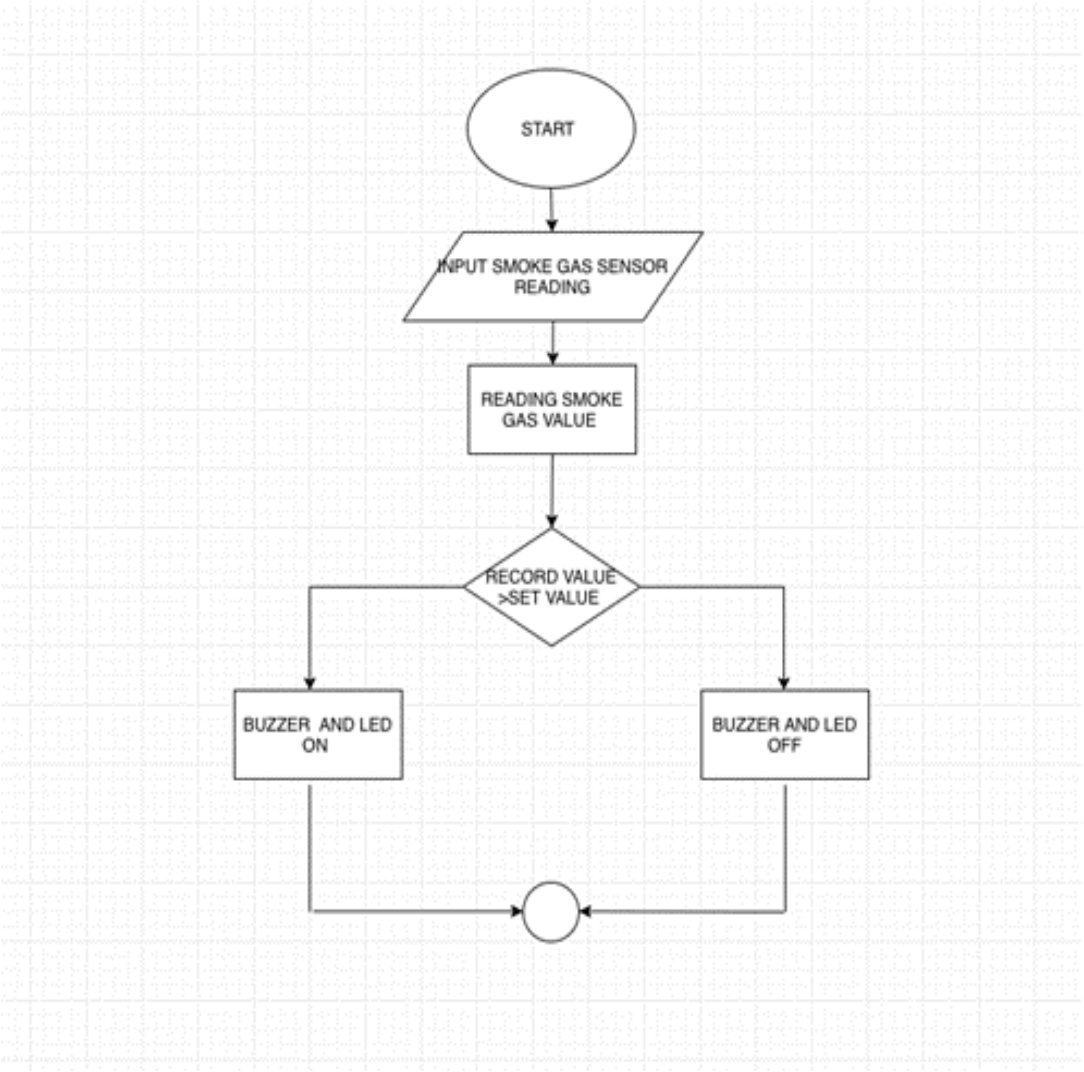

Figure 10 Flowchart of Smoke Sensor

The working of Temperature and Humidity sensor node explained through flow chart as shown in Figure 11. When Temperature sensor will detect rapid increase in temperature, it will get active. The responses will get compared with critical point provided by the user[6]. If the recorded value is greater than the set value, buzzer and LED will on during the incident. Else the system will work normally. After the event is done, sensor will go to sleep mode for energy conservation.

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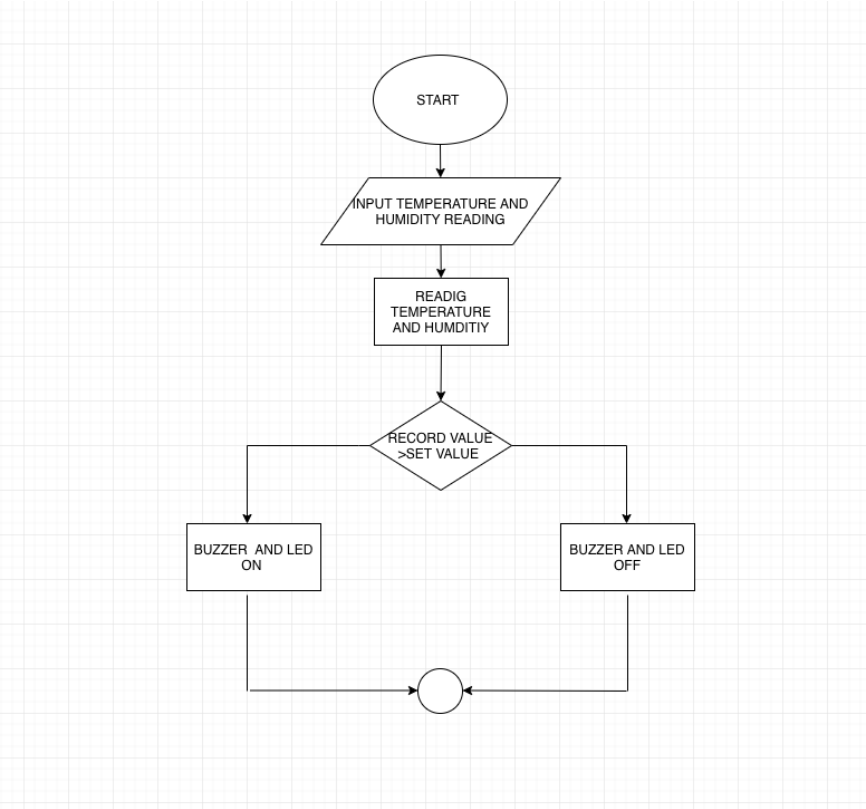

Figure 11 Flowchart of Temperature Sensor

Connections made in this system are represented below node-wise. All connections are made between relevant sensors and using the correct pin configuration. All connections are tested and are working fine. Below certain sample images are provided for reference.

Connection 1- Camera and IR sensor

TheIR sensor is connected with ESP-32 Cam and FTDI programmer [14]. As soon as IR sensor will detect any intruder, it will send signal to ESP-32 cam and Camera module will capture the image and store it in SD card, attached with ESP-32[10]. FTDI USB to TTL serial converter module work as a router and switch. It is supporting all the Operating Systems. The connections are shown in Figure 12.

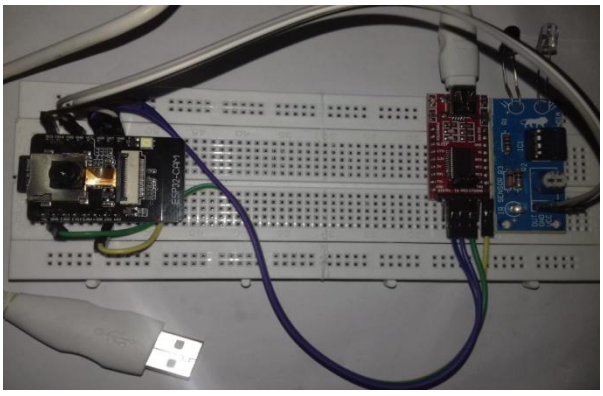

Figure 12 Camera connected with IR sensor

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Connection 2 - MQ 2 Smoke Sensor

Smoke sensor is connected with ESP-8266 Wi-Fi module and Power source[16]. When sensor will detect any kind of dangerous gas, it will send alert to the system and buzzer get active. The complete smoke sensor connections are tested and accurate as shown in Figure 13.

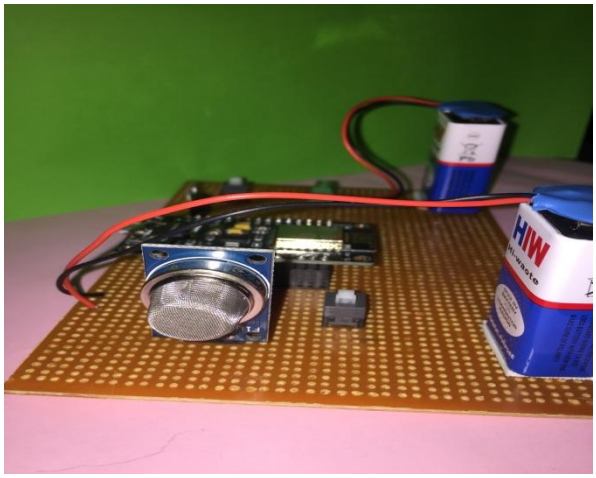

Figure 13 MQ2 Smoke sensor connected with ESP-8266

Connection 3 - DHT 111 Temperature Sensor

DHT 111 sensor is connected to ESP8266 and Power source of 5V as shown in Figure 14which is supplied by battery[16]. It randomly detects the temperature of the surrounding, when temperature of the surrounding wills more than the critical set temperature; it will send alert response to user.

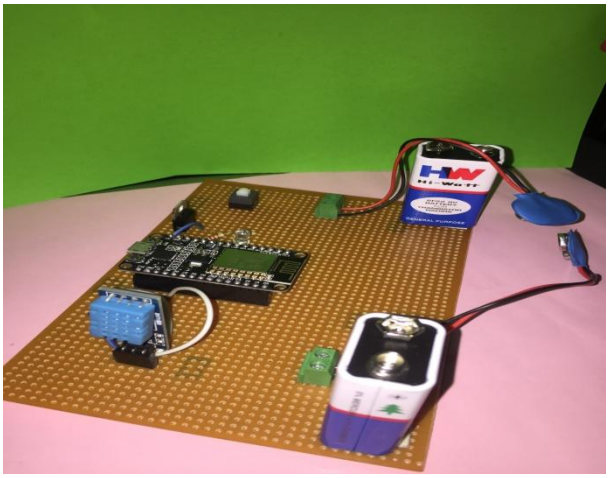

Figure 14 DHT 111 Temperature Sensor connected with ESP-8266

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VI.FINDINGS AND RESULTS

The proposed system can be very helpful in providing security at a low setup cost as the cost of the sensors used in this system is affordable to any other user out in the market. The system captures the image of any individual when he comes into the proximity of the IR sensor and as soon as he is detected, buzzer beeps to give notification as an alarm to the owner or user. Moreover, LED also gets lighted up to distinguish between several categories of mishaps which this system recognizes. Also, the images get stored in the SD card which is fixed inside ESP32 module so that one can identify the person involved in crime.

The system also detects harmful gas and smoke so as to save the organization or any home from some kind of fire or gas leakage. The buzzer and LED give the alarm to user of the mishappening. However, it also detects the sudden rise or drop of the temperature inside the room and also alerts the user about the same. Each node has a unique color LED associated with it, which will glow when that system will trigger an alert.

The main backbone of this project is Wireless Sensor Network. This includes groups of sensor nodes and their base station. The amount of energy consumed in transmitting data from sensors to base-station can be less if base-station is placed in center of sensing field[9]. Also, the system is based on event-driven mechanism i.e. If the sensors will detect any irregular event happening in the range then only, they will get activate else it will remain in sleep mode. Moreover, the sensors used in this prototype consume every low-power for operating and can work even on rechargeable batteries.

User Interface-

User or Administrator is provided with an interface which can be accessed by web as shown in Figure 16. The GUI includes three sections, the first is for “Camera”, this will show the images captured or live view. User can see the image in three resolutions. Second tab is “MQ2 Sensor Response”, this will show the nature of gas and its quantity. Third tab is for “DHT111 Temperature and Humidity Response”, this will show the degree of temperature and humidity recorded by sensor.

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VII. CONCLUSION AND FUTURE WORK

The proposed system can be helpful in areas like home, organization, industries and any high secure area. This system has potential to provide secure at high pace and it can be hidden easily because of its small size. The nodes are easy to deploy and handy. Network involved is highly secure because of flash encryption and speed is also good. The SD card have space of up to 4GB, which is sufficient for storing pictures.

In future, if we take this to a larger scale, it can save much energy and will prove as cost-effective. As the world is currently facing energy issues, so this system can contribute its part. The system can be improved with advance quality of camera and type of storage. Even cloud storage can also be used by upgrading the sensors. Face detection algorithms can be indulged to increase the security checks that can improve the performance of the system and will make it more secure.

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Figure 15 User Interface

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