

# IoT Based Intrusion Detection System Using PIR Sensor

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**Abstract**— Nowadays the need to build an affordable and effective intrusion detection system is a necessity with the events of intrusion or burglary on the rise and as we are approaching towards making our house a smart house in this digital era. The demand for such system is going to increase rapidly if it comes with a feasible price to every household. In most of the prevailing intrusion detection systems, motion sensors are used to detect the presence of an intruder. In this paper, the passive infrared sensor (PIR) is used to detect motion. This paper discusses the application of PIR sensors in such systems and use of ZigBee to create a wireless sensor network and ESP8266 module to send data to a remote server. PIR sensor, being passive in nature is undetectable and work well in the dark environment also. Global System for Mobile communication (GSM) module is also used to send text alerts to the concerned user when an intrusion is detected. Sensor nodes which are implanted in every room send data to the center node when motion is detected. Different sensor nodes which use ZigBee for wireless transmission are all connected to a center node.

**Keywords**- PIR, GSM, ESP8266

## I. INTRODUCTION

The home security systems have grown popular lately as homeowners search for approaches that ensure the safety of their private space and enhance their home values. It is important for the owner to consider incorporating a home security framework as burglaries and trespassing have turned out to be normal in vast urban areas. Recent advancements in semiconductor technology have enabled cost-effective solutions to seamlessly integrate wireless network connectivity in embedded systems and sensors, which in turn lead to keen interest in Internet of Things (IoT) based intrusion detection system which will be effective as well as affordable.

Most of the home security systems use motion sensors along with other sensors. Most widely used motion sensor in such systems is PIR sensor. M. Moghavvemi used PIR sensors in his paper to detect human presence in an area and raise the alarm if an intrusion is detected [1]. He developed a real-time occupancy map on a PC and used frequency modulation technique for wireless transmission. Jaeseok Yun used PIR sensors to find the direction of human movement [2]. He used an array of 4 PIR sensors to find movement in eight different directions.

ZigBee is mostly used in Wireless Sensor Network (WSN) owing to its low power consumption, low cost, and reliable data transfer. Yiming Zhou used ZigBee technology to develop a low cost irrigation system [3]. Dae Man-Han used ZigBee sensor network to design a Smart Home Energy Management System (SHEMS) which divides and assigns

various tasks to different components [4]. R. K. Kodali used PIR sensors and TI CC3320 Launchpad to sense motion and alert the user about intrusion through voice call. However, in his system every module is identical and requires TI Launchpad to alert the user which can add to the cost of the system [6].

We are using PIR sensor to detect motion and ZigBee to create a WSN. The system consists of two units: Sensor node and Central node. The sensor nodes have PIR sensors. When a sensor node detects motion, it sends the details of intrusion to the central node wirelessly through ZigBee. Once the central node receives the details, it sends a text alert to the user's phone through GSM module.

This paper is organized as follows. Section II gives the details about the hardware used in designing the system. Section III shows the design of sensor node and the central node. Section IV shows the proposed algorithm and explain different operations involved within it. Section V shows the results obtained on Arduino serial monitor and ThingSpeak server channel and finally, in Section VI conclusion is presented.

## II. HARDWARE SPECIFICATIONS

### A. PIR sensor

The main component of a PIR sensor is the pyroelectric sensor which is present behind the plastic cap as can be seen in Fig 1. The pyroelectric sensor is actually divided into two halves. When there is no motion, both halves receive the same amount of IR radiations from the surrounding. However, when a target crosses the sensor, the IR radiation level received at one half is more than the radiation at the other half. The PIR reacts to this change and makes the output HIGH. The range of detection goes up to 6meters, and it takes some time to stable itself according to the surrounding when it is powered ON.



Fig 1. PIR sensor

An input voltage of 3-5 V is provided in pin 1 and digital output is obtained from pin 2.

### B. ZigBee

ZigBee is a wireless technology adopted as a global standard for low cost low power wireless communication. ZigBee communication protocol supports multiple network topologies like point to point and point to multipoint. It can allow up to 65000 nodes per network. It is ideal for applications that require short range and low rate wireless transfer like home automation. Due to its low power consumption feature, the transmission is limited to 10-100 meter line of sight. In a network ZigBee can be configured as any one of the following:

#### 1) Router

ZigBee configured as the router can receive and transmit data. It helps in routing data through the network for its transmission over a long range.

#### 2) Coordinator

It is same as the router. The only difference is that it is responsible for starting a ZigBee network. Hence there has to be at least one Coordinator in a network.

#### 3) End Devices

It can only transmit data through the network. Hence it cannot help in routing. It may go to sleep mode, thus saving power consumption to a great extent.

Fig 2. shows a ZigBee.



Fig 2. ZigBee

### C. GSM module

GSM is a mobile communication modem which operates in the 850MHz, 900MHz, 1800MHz and 1900MHz frequency bands. It can perform operations like sending and receiving texts and making voice calls. It is interfaced with the Arduino to send text messages using AT commands. According to the datasheet, GSM SIM900A module requires a power supply of 4.5-12V and a minimum current of 250mA and maximum 590mA [5].

Fig 3. shows a GSM Module.



Fig 3. GSM Module

### D. Wi-Fi Module

ESP8266 Wi-Fi module is a system-on-chip which comes with an integrated TCP/IP stack that can provide any microcontroller interfaced with it, an access to Wi-Fi network. It is also controlled using AT commands and can be programmed either by using FDTI cable or Arduino IDE. In this paper, we are using ESP8266 12E which is programmed using Arduino IDE. Fig 4. shows an ESP8266 Wi-Fi module.



Fig 4. ESP8266

### E. Arduino Mega 2560

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 16 analog inputs, 54 digital I/O pins, 4 UARTS, a power jack, a 16MHz crystal oscillator. It can be powered with a USB cable, an AC-DC adapter, or simply a battery. It operates at 5V but the input voltage can vary between 6-20V. It has a flash memory of 256KB. Fig 5. Shows an Arduino Mega 2560.

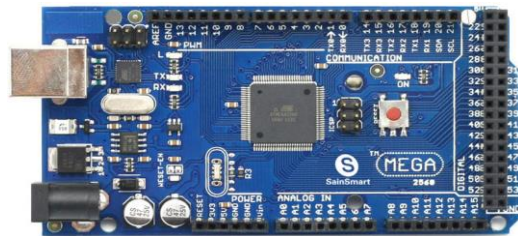


Fig 5. Arduino Mega 2560

### F. IP Camera

The IP Camera is a kind of digital camera that is used for surveillance and can send and receive data through the Internet. The IP Camera used here is Clever Dog Smart Camera which supports all available platforms i.e. Android, iOS, and PC. The app used for accessing the IP camera allows us to view and record the input video at real time. Fig 6. shows the Clever Dog smart camera.



Fig 6. Clever Dog Smart Camera

### III. WORKING CIRCUIT

The circuit of intrusion detection system comprises of two units:

#### A. Sensor node

Sensor node comprises of a PIR sensor, Arduino Nano as a microcontroller, ZigBee (configured as end device) and a power supply. Once PIR sensor detects the motion, it sends the location of the intrusion in the form of a string to the central node through ZigBee. To avoid continuous transmission of such strings due to repeated detection of motion, the Arduino is programmed to check for motion every 7secs. Fig 7. shows the circuit of a sensor node.

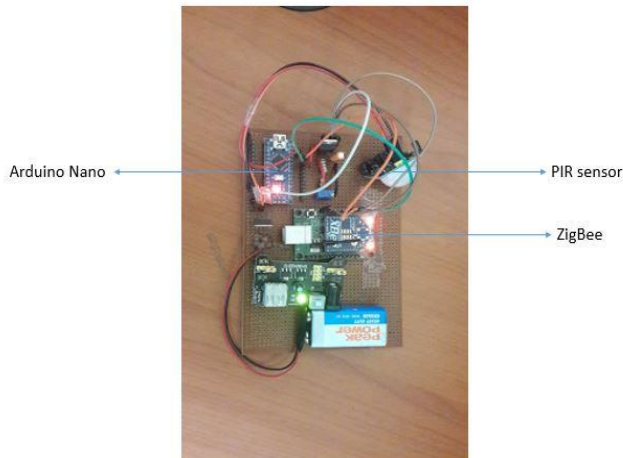


Fig 7. Sensor Node

#### B. Central node

The Central node comprises of Arduino Mega, ZigBee (configured as Coordinator), GSM module, ESP8266 Wi-Fi module and power supply. When an intrusion is detected by any sensor node, the central node regarding the location of intrusion receives a string. The same string is then sent to the user's mobile phone in the form of a text message through GSM module. Also when the intrusion is detected, the PIR

sensor value, which is '1' (digital output) is sent to the ThingSpeak server through ESP8266.

A discreet plot between the PIR value and the time is displayed in the ThingSpeak website using Matlab visualizations tools. The plots can be viewed by logging into ThingSpeak account.

Fig 8. shows the circuit of central node.

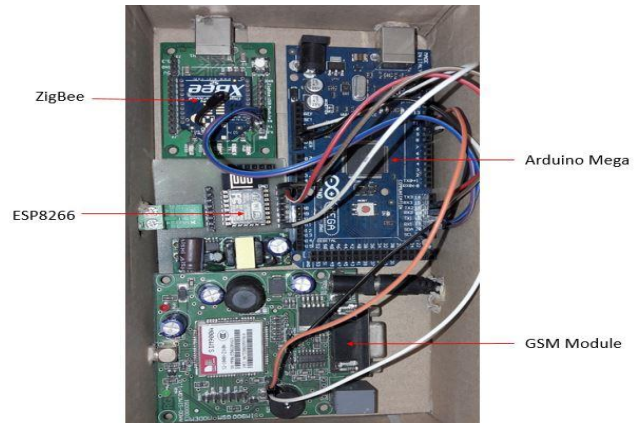


Fig 8. Central Node

### IV. PROPOSED METHOD

The working of the entire system can be described by the following operations:

#### A. Motion detection

A motion sensor can be considered as a linchpin of an intrusion detection system as it detects any movement in space. A motion sensor uses one or multiple technologies to detect motion. In our work, we are using PIR sensor to detect motion. Usually, they are used for in-building and smart home applications to detect motion for directly switching lights or other appliances. It cannot differentiate between an animal and human when intrusion takes place. An IP camera is used to verify the intrusion. It is preferred over other motion sensors because it is passive in nature, which means it does not emit any radiation unlike IR sensors, ultrasonic sensors, etc. It consumes less power as compared to other motion sensors and it can work without getting detected.

#### B. WSN using ZigBee

A Wireless Sensor Network is a group of sensor nodes equipped with any form of communication infrastructure for monitoring and recording different parameters like temperature, humidity, pressure, illumination intensity, sound intensity, motion, etc. Each sensor node consists of a transducer, transceiver, microcontroller and a power source. ZigBee is a transceiver based on IEEE standard 802.15.4 which is used in the Wireless Sensor Network in this work.

C. Alert generation

The proposed system consists of an alert generation system which is used to notify the occupant of the house/office about intrusion once detected. GSM SIM900A is used to generate text alerts and transmit them to a dedicated phone number once an intrusion is detected.

D. Remote server

For monitoring and recording intrusion, a public server by ThingSpeak is used in this paper. ThingSpeak is an IoT application to store and retrieve data over the Internet using HTTP protocol. There are a lot of visualization and analysis tools available to use on the data received on the server. Every new account opened in ThingSpeak comes with a unique key which is later used in the code to send data to the server. The data received can be accessed anytime, anywhere by logging into the account.

ESP8266 12E is a Wi-Fi module which is used here to provide the microcontroller an internet connection. Once configured with an internet source, ESP8266 can send data retrieved by microcontroller over the internet to the remote server. GSM module also provides GPRS services which could be used to get access to the internet. However, accessing cellular data is expensive than Wi-Fi. Now almost every household has Wi-Fi connection. So it would be inexpensive to use ESP8266 for accessing internet connection through Wi-Fi.

E. Surveillance system

Surveillance is a widely adopted technology nowadays. In general, it refers to a mechanism to monitor activities in the desired space. Earlier CCTV devices were used for monitoring an area. But it requires a person to watch every time, and the cost is high to build an entire surveillance system using CCTVs. However, recently surveillance systems have moved from traditional analog to digital and Internet Protocol (IP) based technology which comes with enticing possibilities and affordable price.

IP surveillance is a system which renders the user the ability to monitor activities using an IP-based network like LAN or the internet. Here we are using an IP camera to verify the intrusion. IP cameras like CCTV cameras can be used round-the-clock to monitor activities if they are connected to the internet but it would be futile to do so if there is no intrusion as it would consume time and a considerable amount of data unnecessarily. However, when the user receives a text alert about the intrusion, IP camera could be used to verify the source of the intrusion. The user can open the application that supports the IP camera in his mobile or PC to get live feed. Henceforth he can act accordingly.

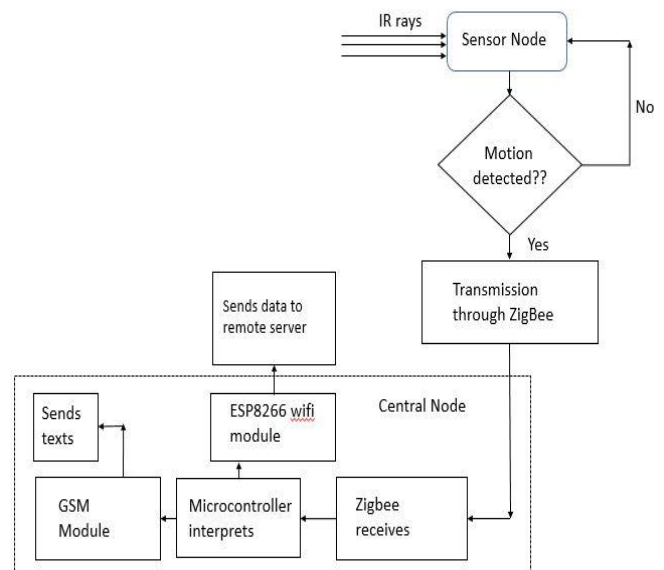


Fig 9. Flowchart of working algorithm

Fig 9. shows the flowchart of working algorithm. The sensor node detects motion and relays the information of intrusion to the central node which generates text alert to the user’s phone and sends sensory data to the ThingSpeak server. Once the user receives the alert about the intrusion, live feed can be obtained on the user’s phone through the IP camera.

V. RESULTS

The results are obtained on the Serial monitor. Fig 10 shows the serial monitor, which shows the simulation results of the AT commands that are used to send data to the ThingSpeak server when an intrusion is detected. Fig 11 shows the ThingSpeak channel where the data are logged in. Fig 12 displays the plot between PIR sensor value and time using a Matlab visualization tool.

```

y|AT+RSTconnecting
connecting
module is working
motion detected in room no ec/306;1    1
connecting
connecting
OK
Connected
in the update loop
AT+CIPSTART="TCP","184.106.153.149",80
AT+CIPSEND=49
>GET /update?api_key=MOD10PHIBDYJ03Q7&field1=1

motion detected in room no ec/306;1    1
connecting
connecting
OK
Connected
in the update loop
AT+CIPSTART="TCP","184.106.153.149",80
AT+CIPSEND=49
>GET /update?api_key=MOD10PHIBDYJ03Q7&field1=1
    
```

Fig 10. Simulation on Serial monitor of Arduino mega

used for creating a wireless sensor network (WSN). The PIR sensor is used for detecting the movement of people, animals or any object. Once the sensor encounters the motion, a text alert is generated and sent to the user through the GSM module, and the ESP8266 sends the sensor data to a public server (ThingSpeak) which displays the plot between time of intrusion and the sensor value. This system consumes less power, is of low cost, easily operable and easy to install in comparison to existing intrusion detection systems. Finally, when the user receives the text alert, he can use the IP camera to access the live feed remotely.

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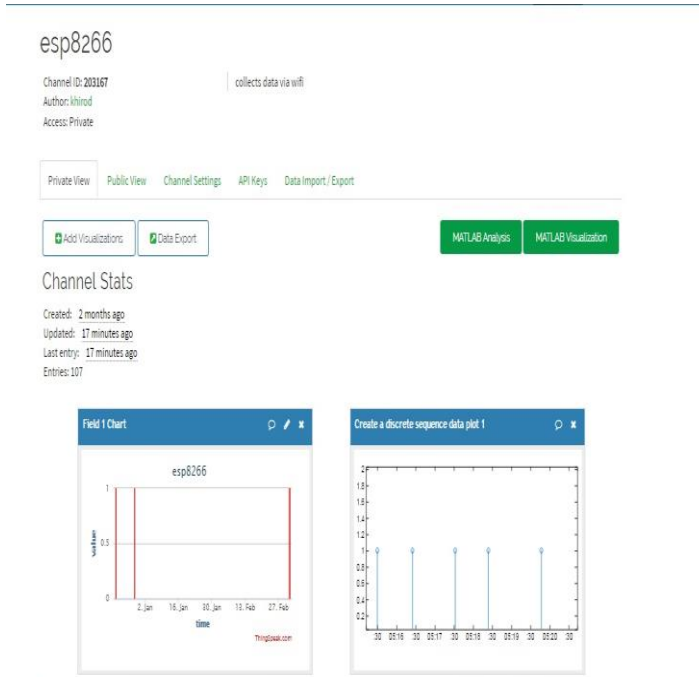


Fig 11. ThingSpeak channel

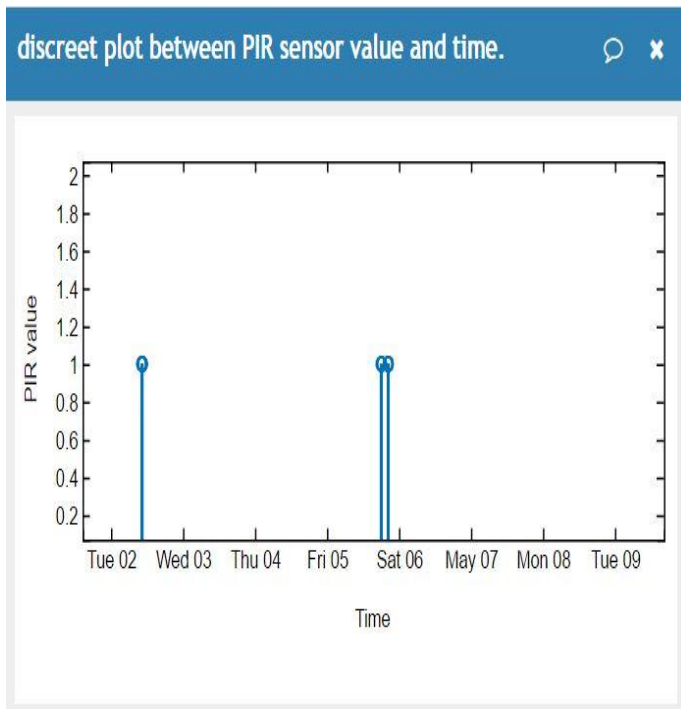


Fig 12. Matlab visualization tool in ThingSpeak channel

VI. CONCLUSION

This paper presents the design and implementation of an intrusion detection system using PIR sensor. ZigBee here is