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Smart Border Security System Using Internet of Things

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Abstract: *National security and defence is incredibly important for a country and its people. For increasing tension in the border areas due to unresolved conflicts, currently national security systems emphasize more on border security to protect the country from terrorist attacks, ille- gal border crossing and infiltration from the neighbouring countries. To make security system more efficient, a real time border security system is needed which can provide 24 hours surveillance in the border areas with high accuracy and that can minimize the need of human involvement by utilizing the most advanced sensors and actuators. Indian Border Guard- ing forces are already installing and adopting newer technologies in terms of cameras, night vision devices, radars etc. But for the efficient and in- telligent use of collected data, involvement of modern and innovative technology like Internet of Things (IoT) is very necessary, which already has been adopted but in very small scale and in limited areas. Whereas, it is the reliable source of accurate data and renowned for smart and fast decision making as it is one of the major fields of implementing Big Data and Analytics. So, a smart IoT based solution has been introduced for securing hazardous border areas with extreme climatic conditions, diverse land forms, river terrains, inaccessible dense forest areas which is very tough to monitor for the individual. This paper "Smart Border Security System using Internet of Things" proposes a low-cost system that uses various sensors like Passive Infrared (PIR) sensor and OV7670 camera module to sense movement of any object within a range and cap- ture images of intruder respectively. The system can upload the sensed data into a cloud server which can be retrieved in a base station by using web and desktop application as well. The system can also send alert to the base station by processing the sensed data. Also, it allows user i.e. the trained security personnel to control the camera and retrieve data from it from a distant. Through the proposed system it is possible to detect the intruder crossing the border area instantly.*

Keywords: Internet of things, Border security system, Passive infrared sensor

I. INTRODUCTION

Border security is incredibly important to guard vulnerable and valuable assets like an individual, dwelling, community and nation from any harmful activities of an intruder. Universal security issues are imperative, particularly border and coast security to any nation. Border zones are commonly considered as spots where massive brutality, interruption and dispute between several forces occurs. Topography like mountains, cold regions, deserts, unforgiving climate and wa- ter bodies frequently lead to troublesome access and observing of outskirt zones [1]. Smart border security system using Internet of Things is an innovative idea to secure our border areas smartly and efficiently with minimal deployment of military in hostile zones.

According to a report of Federation of Indian Chambers of Commerce Indus- try (FICCI), forces of the Indian territory is focusing mostly on implementing advance technology like IoT to improve the efficiency and effectiveness of bor- der operations These systems comprises of a sensor layer applied in a planned manner to allow a layered defence mechanism; network backbone, which allows real time data transmission from the field locations to the relevant stakeholders, base command centre, where data can be observed and analysed, decisions are taken, also response process has been launched by the Stakeholders[9]. The com- bination of traditional methods with current technologies like Internet of Things (IoT) and Wireless Sensor Networks(WSN) can lead to advancement of security system.

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The concept of connected device was first introduced since the 70s but the actual term Internet of Things was established by Kevin Ashton [2]. It may be depicted as an group of interconnected computing devices consisting of mechanical and digital devices, any items or any living beings.The Internet of Things objects con- sist of sensors, software, network connections and necessary electronics and it empowers them to gather and exchange data and make them responsive. On the other hand, Wireless Sensor Network (WSN) can be described as a distributed network of some devices feature capable of local processing and wireless com- munication [12]. Sensors are used to collect information from a physical environ- ment, Whereas WSN is responsible for establishing connection and transmitting data to the server.

In this paper, a smart border monitoring system using Internet of Things is proposed. The main objective of the proposed system is to design a device that can automatically detect the intruder crossing the border areas. The system will help the border security forces to protect the border areas smartly and efficiently with minimal deployment of forces in hostile zones.

The rest of this paper is organized as follows. Section 2 presents recent litera- ture review related to border security systems. Section 3 presents the architecture of the proposed system, module design and working principle of the system. Sec- tion 4 discuss the experimental results. The paper concludes with future research direction in section 5.

II. LITERATURE SURVEY

Being one of the largest country, India has a very large border of around 15,106.7 km along the side of China, Nepal, Bangladesh, Pakistan, Bhutan and Myanmar.

Due to unsafe and compel border structure, it gets to be troublesome to oversee and secure the boarder [3]. Many research works done by the students, Professors and research scholars on this field of Internet of Things (IoT), have been inspired as well as helped to do this project in field of IoT. Also the online resources, surveys, blogs and research papers gave light to the way of work, and helped to progress. Hopefully this project will meet all the support, functional and performance expectations of the user. As a reference we can take the following research paper and architecture of the developed system. As a reference we can take the following research paper and architecture of the developed system.

In [1], a system based on WSN(Wireless Sensor Network) and IoT, has been developed by using Raspberry pi, ESP8266, PIR and sound sensors, a 180 degree controlling motor, two types of Camera(FLIR and night camera), laser pistol and a buzzer. A control station have been set up to establish a communication link within the borders using 2 routers. On movement detection by the sensors, the electric shocker is activated by raspberry pi, also alert is sent to the control station by ESP8266 WiFi module. Horizontal and vertical movement of intruder can also be detected by electric motor. Electric shock can be controlled by con- trol station. The use of both wireless and wired communication increases the reliability of the system. More usage of hardware and their collaboration has made the system very efficient irrespective of season and geographical location.

G. S. Nagaraja and Shreyas Srinath have been introduced an IoT based se- curity architecture implemented in a small scale area in [4]. Proposed IoT based smart home system is designed and implemented to make home or private prop- erty more secure which is user friendly also. Sensors used in this proposed sce- nario are Infrared Rays(IR) sensor, PIR sensor, water flow sensor, temperature and humidity(DHT11) and current sensors, used for turn on or off lights and automatic control of gates, detect human being's presence, to water the garden accordingly with moisture level, to monitor electrical components like light bulb, fan, AC etc. respectively. Wireless sensor network has been implemented by Zig- bee technology and Raspberry Pi, running on MQTT protocol, has been used as controller. Mobile application is there for controlling the appliances remotely by the user.

In [7] H Salman ET Al have been developed a low cost real time IoT based solution for home security which includes IR camera, controlled by Raspberry Pi 3B for capturing image, Haar cascade algorithm and LBPH algorithm for face recognition, and also notification system in case of unknown face detection. SQlite along with my SQL has been used to update the database to the web server. The proposed embedded system using Raspberry Pi 3 connected with PIP camera, using the camera, computer vision is utilised to process the taken image by image processing algorithm to recognise the face. LBPH face recognizer has been used for training the data. The trained data was saved as XML or YML format. For testing the data Haar cascade algorithm taken from OpenCV library has been used and implemented

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in python programming. In the wake of recognizing the picture, it contrasts and the pictures of the client's database. 87% face recognition accuracy has been mate. If different image is detected from the user's database the system subsequently send SMS and email, along with the unknown image, to the user's smartphone. This system uses SMTP protocol for sending email to the user. An IoT based application Twilio sms python api has been used in this system for sms service.

[5] have introduced an IoT based Frontier security and tracking system en- compassing with a threshold based algorithm for the effective tracking of boats in the sea. Proposed system encompasses Raspberry Pi 2 as IoT kit and differ- ent components such as GPS tracker module, weather forecasting sensors, relay circuit, LCD display and Android application that facilitate effective monitor- ing and forecasting of unfortunate events in the sea frontiers.This application consists of integrated water alarm which helps the fisherman in an efficient way. Threshold value sets at 5 km from the border line. System triggers an alarm as well as sends an alert message when the fishing boat is near the threshold limit of 5 km. Due to unforeseen circumstances if the boat crosses the nautical border relay circuit will be turned off which is start and shutdown the system. The proposed system helps the fishermen to easily identify the sea frontiers of the countries and they are prevented by entering into other country frontiers by adaptive algorithms.

On contrast to the above cited papers, the proposed framework is considerably a low-cost solution as number of hardware and sensors used are less. Unlike [1], we are not taking automatic action against intruder, but providing real time data to the security personnel for better decision making, also the proposed system is lightweight compared to the systems introduced in [1] and [4], that makes it fit to be used in complex land forms. Although the systems introduced in [4] and [7] are mainly built for small scale area like house, building and private property, and the real time IoT framework introduced in [7] using IR camera, is built to take action by detecting face, but our proposed work combines both the method- ology more or less, to introduce a new system that is more compatible and easy to use for the security person who might not be well trained or irrelevant with technology. As the proposed system is a low cost IoT based solution, it can be deployed in a large number. Unlike [5], the introduced system can be suitable to use not only in the coast line, but in any hardly accessible areas like swampy marshes, snow-covered peaks and tropical evergreen jungles, difficult and varied terrain etc.

III. PROPOSED SYSTEM

This section presents the architecture, module design, system methodology and working principle of the proposed system "Smart Border Security System using Internet of Things". The proposed system uses sensors, micro-controller board and wireless network to develop an effective device that can automatically detect the intruder crossing the border areas. The system has the ability to notify user by analysing the data collected from the intended border area. The data is uploaded in a cloud server that can be used to analyse the sensory information in order to activate the camera module to capture images of the intruder. The proposed system is more beneficiary than the traditional security system.

Architecture

The system has been developed with the combination of hardware and software components. The hardware part consists of passive infrared (PIR) motion detec- tion sensor, OV7670 camera sensor, Ardiuno micro-controller board, resistors, connectors and printed circuit board. The software part consists of Arduino IDE, Thingspeak web server, serial port reader. Programming language used are Java, C++. For building up an insightful security gadget dependent on IoT

- M2M framework, sensor network and database management are the founda- tions.Architecture of the system has been shown through block diagram in fig 1 where all the hardware is connected with the arduino micro-controller board. The flow of data is shown with arrow mark. Arduino is going to switch on PIR sensor as soon as power supply turns on. Data collected from PIR sensor will be sent to cloud server through ESP8266. Also Arduino will send alert to the control room. On the other hand user can turn on camera module by sending signal to the Arduino board via USB cabel.

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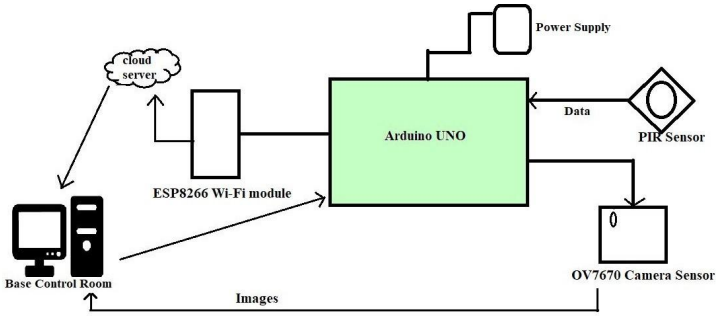

Fig. 1. Architecture of the proposed system

Module Design

In this section, we are going to discuss about design of different modules that combines to make the whole system. As mentioned earlier, we have divided the whole system in two modules. The given figure 2 shows the first module, hardware connection of Arduino board, ESP8266 Wi-Fi module, PIR motion Detector sensor[11] and alarm.

In the second part of the module, according to user input Arduino is going to turn on and turn off OV7670 camera module. User can control the camera module via Arduino microcontroller, like selecting port, start clicking photos and also can stop taking photos. User can save images in the system if required. Circuit diagram of this module is shown in figure 3 which describes connec- tions between OV7670 Camera module and Arduino board. User can control the camera module through Serial Port Reader Software made for OV7670 camera module[6] which is shown in figure 4.

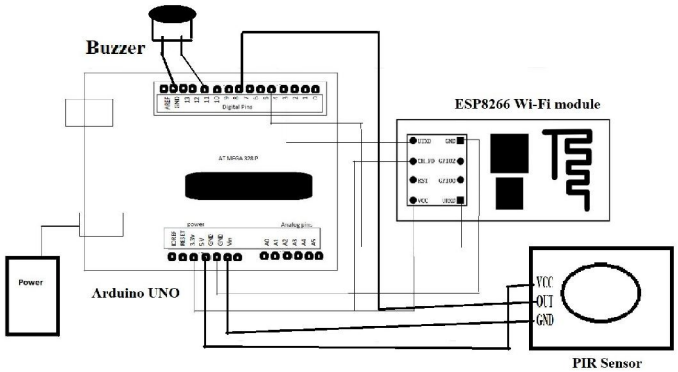

Fig. 2. Circuit diagram of module 1 (i.e. connection of Arduino with ESP8266, PIR sensor and alarm)

System Methodology

In the first part described in figure 5, PIR motion detector sensor is connected to the Arduino board with connectors. It has 3 pins - VCC, GND, and analog out pin. Among the pins A0, GND and VCC pins are connected to the Arduino Board. The Arduino board is receiving the sensor data through A0 pin that is connected to the sensor. The Arduino UNO microcontroller board based on ATmega328p has 14 digital input output pins and 6 analog inputs with a USB connection and a Power Jack on it. ESP8266 Wi-Fi module consists of 8 pins with patch antenna and a processor.

RX and TX pin is used for data transmission and reception purpose. The data received by the sensor is uploaded in cloud server with the help of Wi- Fi module. Wi-Fi module uses wireless connection to upload the data into the server. In the proposed system ThingSpeak IoT platform[8] has been used as cloud server as they are providing free cloud storage. A buzzer connected with the Arduino board act as output device to send alert in the base station. How- ever, this proposed model is quite small model, to implement it in a bigger area user can use more strong and reliable buzzer or alert system also. In the second part of the system described in figure 6, OV7670 Camera module is interfaced with Arduino board. It works on 3.3 volt, but Arduino GPIO pin provides 5.5 volt power. So we have to use resistors to

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connect these two hardware. We have used 10k and 4.7k resistors. This image sensor is controlled using Serial Camera Control Bus (SCCB) having a maximum clock frequency of 400KHz. SCCB, which an I2C interface uses SIOC and SIOD pins to connect with the analog pins of Arduino. Handshaking pins like VSYNC(Vertical Sync Output), PCLK(Pixel Clock Output), HREF(Horizontal Reference), XCLK(System Clock) are con- nected with the digital output pins of Arduino board. Rest of the digital pins are connected with the digital pins of OV7670 to get 8-bit YUV/RGB Video Component Digital Output.

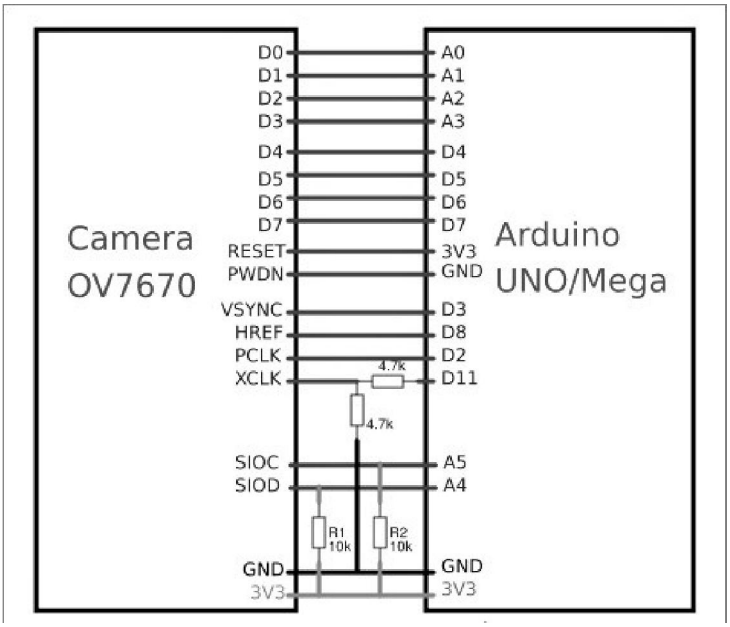

Fig. 3. Circuit diagram of module 2 (i.e. connection of Arduino and camera module)

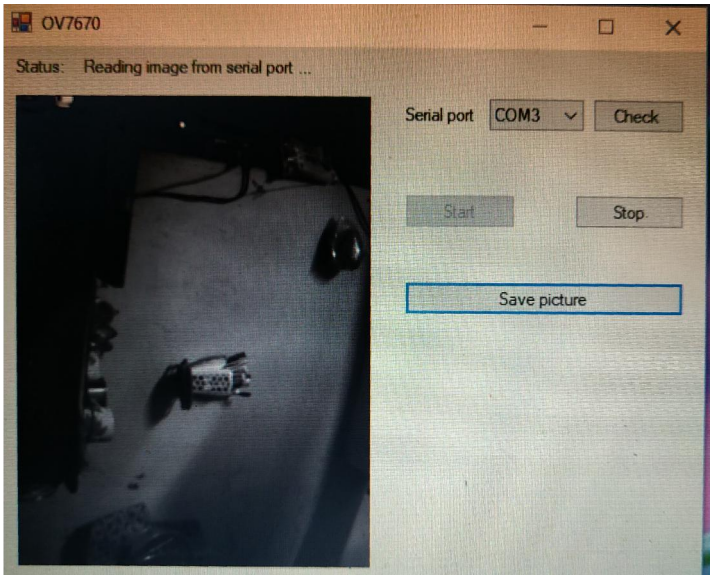

Fig. 4. Serial port reader interface

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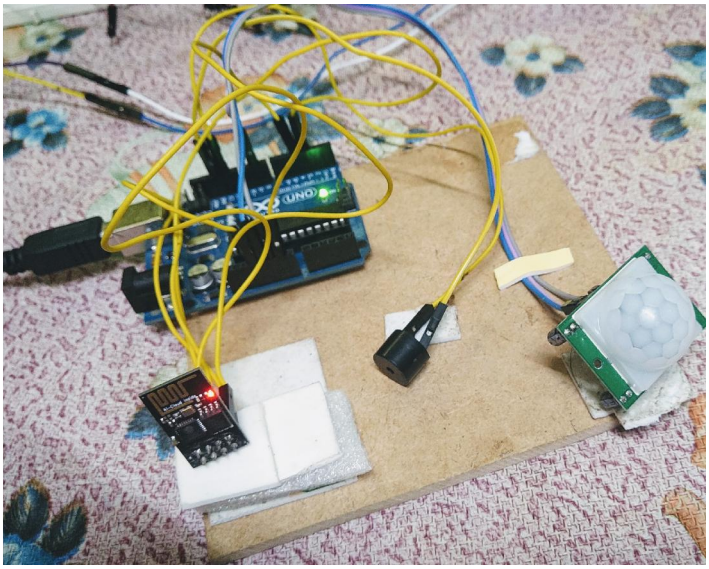

Fig. 5. Hardware connection of module 1

IV. WORKING PRINCIPLE

The system is developed using Arduino board and coding is done using Arduino IDE [10]. Firstly, the PIR sensor is turned on to check motion detection. Along with this, according to the program on Arduino output signal is generated and alert is sent to the base station. The analyzed data is farther stored in the SQL database provided by the ThingSpeak IoT platform using URL command line tool and library through HTTP protocol. On the other hand, for controlling the OV7670 camera module, there should be Serial Port Reader software installed in the system which reads image sensor data through USB cabel. Code uploaded into Arduino captures images as per user request, user can fetch data via the Serial Port Reader interface. The workflow of the system is represented in the following flowchart in figure7

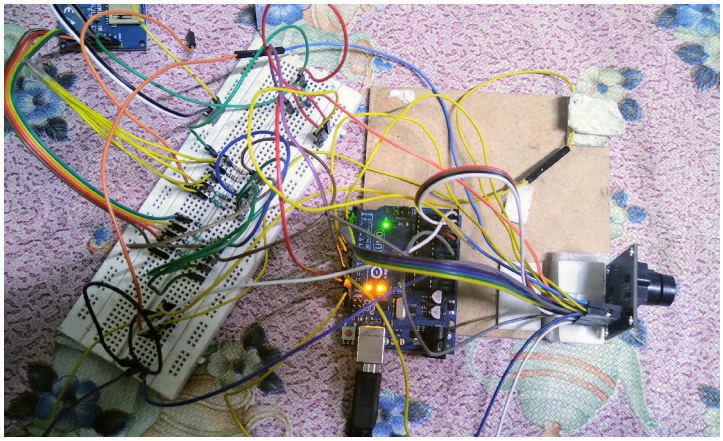

Fig. 6. Hardware connection of module 2

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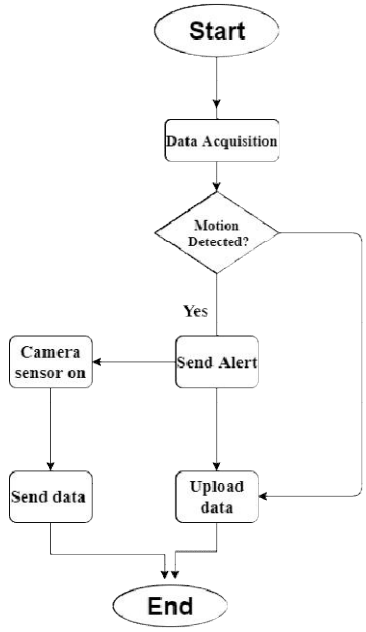

Fig. 7. Flowchart of the proposed system

V. EXPERIMENTAL RESULT

The system is tested in room temperature and in low light area to understand the feasibility of the camera. Our experiment has been conducted separately for both the module as mentioned earlier in section 3. Experimental output, briefly described in the table 1 and table 2 to show the automated working of PIR sensor and Image sensor respectively. Each experiment returned success full result as desired.

Table 1. Experimental Result Obtained : part1

Sl No.	Test Case Description	Desired Output	Actual Output	Status
01	Test the working of PIR sensor by connecting it's 3 pins to the Arduino. It should detect motion .	If motion is detected the PIR sensor will return 1.Data can be seen in serial port.	PIR sensor returning 1 if motion detected, otherwise sends 0. Data is showing in Serial Port	Successful
02	ESP8266 should upload sensor data into cloud server	Graphical representation of data need to show in Thingspeak website.	Graphical representation of data showed in Thingspeak website.	Successful
03	Arduino should send alert through output pin	Buzzer should ring if motion detected	Buzzer rang when motion detected	Successful

Table 2. Experimental Result Obtained : part2

Sl No	Test case Description	Desired Output	Actual Output	Status
01	Serial Port Reader check the port number if OV7670 is connected successfully	Port number will be shown in window	port number showed	Successful
02	Camera data will be shown in the window when user will click start button .	Camera data is viewed in the window	Images displayed	Successful
03	Last updated image will be shown when stop button clicked	camera will stop working and window showed last updated image	Camera Stopped	Successful
04	User can save Picture by clicking on save picture button	User save picture with desired file name and file extension.	Image saved in the system	Successful

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Also user interface in Thingspeak web application has been shown in fig- ure 8 where user can frequently monitor the status of the sensor by observing the graphical representation. The analysed data is stored in the SQL database provided by the ThingSpeak IoT platform using URL command line tool and

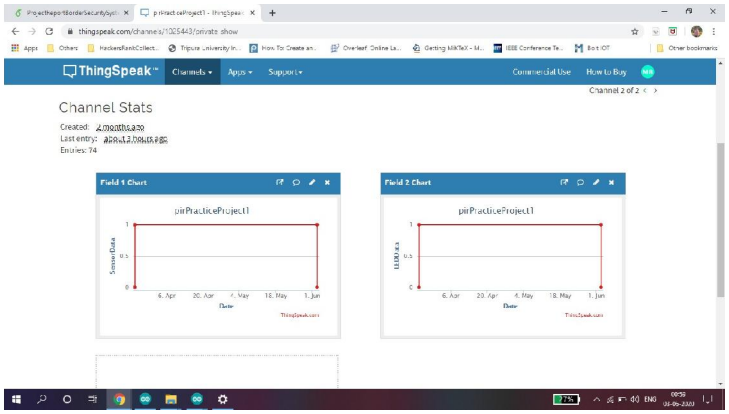

Fig. 8. Snapshot of graphical representation of Sensor data in Thingspeak Web Application

library through HTTP protocol. In figure 9, snapshot of the folder containing collected data by the Serial Port Reader software have been shown. However, user obtains live data on the software, also save images in the system if required by simply clicking on the save button of the software interface as shown in figure 4.

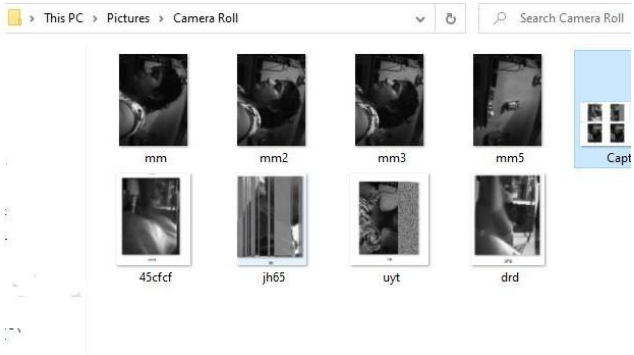

Fig. 9. Snapshot of collected data by OV7670 Image Sensor

VI. CONCLUSION AND FUTURE DIRECTION

The paper proposed a cost effective smart border security system using Internet of Things. The system can detect the intruder crossing the border areas, thereby helping the border security forces to monitor hostile zones of border areas efficiently with less manpower. The use of pocket friendly but reliable equipment makes the system more useable. Presently, the system is developed for small scale area. To implement the system in larger area in near future, a central base station will be required to control the substations in that area. Then, periodical status transmission to the central base station will be possible. Moreover, more attention will be given on improving the user visualization to improve data re- trieving performance. Further research can be done to improve the functioning and features of the system.

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