Development of IoT based Smart Security and Monitoring Devices for Agriculture

Tanmay Baranwal
Department of Computer Science
Lovely Professional University
Phagwara, Punjab
tanmaybaranwal@live.in

Nitika
Department of Computer Science
Lovely Professional University
Phagwara, Punjab
nitikarajput95@gmail.com

Pushpendra Kumar Pateriya
Department of Computer Science
Lovely Professional University
Phagwara, Punjab
pushpendra.mnnit@gmail.com

***Abstract*—Agriculture sector being the backbone of the Indian economy deserves security. Security not in terms of resources only but also agricultural products needs security and protection at very initial stage, like protection from attacks of rodents or insects, in fields or grain stores. Such challenges should also be taken into consideration. Security systems which are being used now a days are not smart enough to provide real time notification after sensing the problem. The integration of traditional methodology with latest technologies as Internet of Things and Wireless Sensor Networks can lead to agricultural modernization. Keeping this scenario in our mind we have designed, tested and analyzed an 'Internet of Things' based device which is capable of analyzing the sensed information and then transmitting it to the user. This device can be controlled and monitored from remote location and it can be implemented in agricultural fields, grain stores and cold stores for security purpose. This paper is oriented to accentuate the methods to solve such problems like identification of rodents, threats to crops and delivering real time notification based on information analysis and processing without human intervention. In this device, mentioned sensors and electronic devices are integrated using Python scripts. Based on attempted test cases, we were able to achieve success in 84.8% test cases.**

***Index Terms*—Internet of Things (IoT); Agriculture; Security; Raspberry Pi; Sensors; Wireless Sensor Network (WSN);**

I. Introduction

Over the past years information and communication technologies have been introduced in agriculture, improving food production and transportation[1]. However the integration of these technologies are not yet used for security puposes. The significant challenge facing the security in agriculture is the interaction between security devices and to provide them intelligence to control other electronic devices such as cameras, repellers etc to enhance security in various fields. For example, a basic CCTV camera installed in a grain store cannot be of use until recorded media is accessed and it also cannot process the information about what is happening at particular location. In implementation and adoption of information and communication technologies, cost is also a major factor. It is not easy to achieve exchange of information among devices and upgrading their functionality while keeping their cost to a reasonable level [2]. So, the natural conclusion is that the security and monitoring systems must be responsible for transmitting data over network, analyzing the information and notify the user with real time information of surroundings.

This lack of information transmission and data analyzing has been "solved" by integration of internet of things with currently available security devices in order to achieve efficient food preservation and productivity. Although the food crop loss and debilitation of diseases are due to various threats as rodents, pests, insects and grain pathogens, while this research is the designing and analyzing of security device, considering damages to post harvest crop by rodents and grain stores as applicable area.

In the context of Smart Security and Monitoring System for Agriculture (S2MSA), we address the challenge of integrating Internet of Things with electronic security devices and systems to improve the efficiency of food preservation in grain stores.

A. Internet of Things

Kevin Ashton in 1999 proposed the term "Internet of Things" to refer inter connected devices[3]. It's a major tech revolution in information and communication technology with updated infrastructure and and networks where all the connected devices are able to identify and communicate with each other [4].

According to Gartner, in near future, about 25b identifiable devices are exepected to be a part of this computable network by year 2020 [5]. Thus, agriculture can be a vast area to integrate Internet of Things with distributed autonomous sensors to monitor environmental condition of grain stores and to analyze data and pass the information to remote user.

B. Wireless Sensor Network

Wireless Sensor Network abbr. WSN is a distributed collection of small devices, capable of local processing and wireless communication [6]. As the implementation of wireless communication technologies in industrial areas are necessary due to inaccessibility to remote location at everytime, to transmit the informations generated by sensors along with controlling them. So, to achieve interoperability between devices in industrial areas, design and implementation of wireless communication system is done [7].

The structure of report is as follows. In Section II the literature review, includes theoratical contribution and analysis of current security devices and technologies. Section 3 discusses the Research and developement methodology of device in

978-1-4673-8203-8/16/$31.00

which we present our architecture and design modules and the data transmitted between them. Section 4 presents example on how our device operates and the statistics of efficiency. Finally, Section 5 concludes the paper.

II. Review of Literature

For developing an intelligent security device based on IoT, M2M framework, sensor network and database management are the foundations. The fields like data analytics and pattern matching also influences security devices. Researchers have been developing various IoT based security devices but a little work is done in agricultural area.

According to previous research in crop's security, developing countries, which are using traditional storage facilities for staple food crops, can't protect them, leading to 20-30% loss of agricultural products such as rice, corn etc[8]. Currently available solutions targets only insects, pests and grain pathogens. While other study states 5 to 10% loss in rice crops on average, in Asia is due to damage caused by rodents[9]. These rodent impacts are also associated with the debilitating rodent borne diseases. As in Asian and Pacific countries death rate due to rodent borne diseases is higher in comparison with some illness such as HIV-AIDS (Table - I).

TABLE I
Comparison between HIV-AIDS and Leptospirosis based on deaths and cases found (Philippines)

Source: Grant R. Singleton. 2010, ''*Impacts of rodents on rice production in Asia.*'', & PIDS, NEC, Department of Health, Philipinnes

Disease	2008		Jan-Oct 2009	
	Cases	Deaths	Cases	Deaths
HIV-AIDS	528	4	629	1
Leptospirosis	832	41	2777	161

Rodents damaging agricultural products is a problem to be managed by promotion of intensive smart agricultural systems and support systems for farmers that derives by monitoring data should also be developed for rodents [9].

Based on smart agriculture, by using information and communication technologies, internet of thing can provide us with a security system for private fields and farm products, thus improves the monitoring and security of pre-harvest and post-harvest grain.

Distribution of resource, delegate control of devices and balance of loads to improve efficiency of resource devices are using, is achieved by integration of hardware resources into clustures using vitalization technology. To obtain large amount of data, by using various information sensing techniques of IoT using RFID, wireless communication etc. are integrated with agricultural based information cloud to form smart agricultural device[10].

Data collection is also a major part in security devices. Here, data i.e. sensory information using various sensors. Information generated from sensors are transmitted to server or platform (IoT based M2M platform) over network so that it can be accessible through remote location for further processing and monitoring. Once the data is transmitted to the server, client machine is used to access it, process it and notify user based upon filtered information [7].

Internet of Things is used with IoT frameworks in order to easily view, handle and interact with data and information. Within the system, users can register their sensors, create streams of data, and process them. In addition, the system has searching capabilities, helping the user with a full-text query language and phrase suggestions, allowing a user to use APIs to perform operations based on data points, streams and triggers. It is also applicable in various agricultural areas apart from security. Few areas are :

- Water quality monitoring
- Monitor soil constituent, soil humidity
- Intelligent greenhouses
- Water irrigation
- Scientific disease and pest monitoring

To develop more cost efficient system by avoiding the need of maintainance, free from geographic constraints and to access affordable services, extended "as-a-Service" framework in cloud computing can be integrated with Internet of Things to deliver financially economical IT resources[11].

A. *Thing-as-a-Service*

In IoT and Cloud era, sensing, actuation, data generation, storage, and computation has extended the cloud services ahead of SaaS, IaaS, and PaaS. Thing-as-a-Service is introduced in order to develop a cloud of Things where different kind of resources as sensors can be integrated based on the tailored thing-like schema.[12].

III. Research Methodology

In the proposed scenario, the research problem is to develop intelligent security systems with ability to analyze data and transmit information over network to the remote location. Literature survey gives the notion about present work done in field of agriculture security and IoT. This can be enhanced by integrating few new technologies with present scheme. Current IP based CCTV security cameras require network connectivity for monitoring from remote location. It doesn't has ability to notify user by analyzing data. In the device, basic sensors and electornic devices are used. The sensory information are analyzed in order to activate electronic devices and raspberry pi is used as a server to analyze data and transmit information to user.

Components used are :

1) Rapberry Pi 2 Model B+
2) PIR Sensor
3) Ultrasonic Ranging Device
4) Web Camera
5) Ultrasonic Sound Repeller

Platform and Language Used :

1) PTC's ThingWorx's IoT platform for M2M Services
2) Python
3) Linux based Raspbian OS

A. Architecture

Device uses 3 interface for data collection, analysis and transmission. IoT architecture is categorized in 3 level architecture and five level architecture. Figure - 1 shows the working phenomena of device based upon 3 level architecture[13].

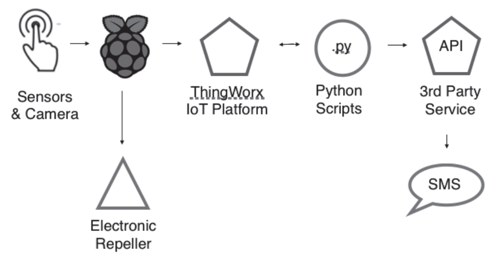

Fig. 1. Device's Architecture

These layers, categorised as

- Perception layer : Layer which is used to differentiate the different type of sensors used in device.
- Network layer : Layer used for process and transmit the information over network.
- Application layer : This layer is responsible for various practical application based on users' need.

Extra key level mentioned between application layer and network layer is known as middle-ware layer which consists of data analyzing system to take automated actions based upon information [14]. This layer provides dedicated services among connected devices[15].

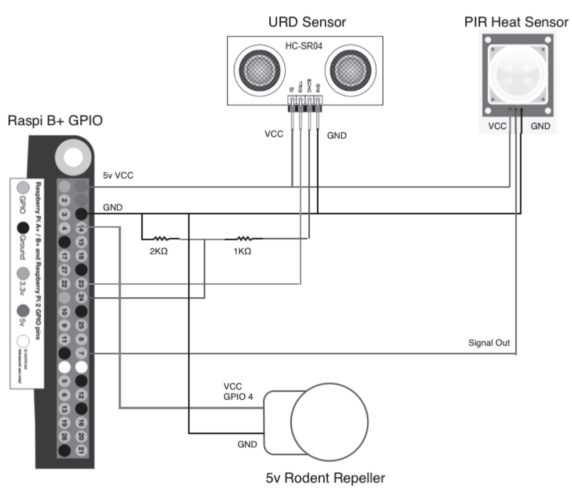

Fig. 2. Device's connectivity using RasPi's GPIO Header

B. Circuit Design

The sensors and camera is connected to GPIO header. PIR sensor has three pins as VCC, OUT and GND, while ultrasonic ranging device (HC-SR04) contains four pins as TRIG, ECHO, VCC and GND. Device also contains a ultrasonic sound based rodent repeller which will be activated by server based upon data analysis.

Raspberry pi B+ GPIO header (Table-II) is consists of 40 pins which includes 5v, 3.3v, GND and 26 GPIO pins and 2 ID-EEPROM pins to provide connectivity to I/O devices.

TABLE II
GPIO HEADER PIN OUT

Source: GPIO Models A+,B+ and Raspberry Pi 2 @ https://www.raspberrypi.org/documentation/usage/gpio-plus-and-raspi2/

PIN	GPIO	PIN	GPIO
1	3.3v	2	5v
3	GPIO 2	4	5v
5	GPIO 3	6	GND
7	GPIO 4	8	GPIO 14
9	GND	10	GPIO 15
11	GPIO 17	12	GPIO 18
13	GPIO 27	14	GND
15	GPIO 22	16	GPIO 23
17	3.3v	18	GPIO 24
19	GPIO 10	20	GND
21	GPIO 9	22	GPIO 25
23	GPIO 11	24	GPIO 8
25	GND	26	GPIO 7
27	ID-EEPROM	28	ID-EEPROM
29	GPIO 5	30	GND
31	GPIO 6	32	GPIO 12
33	GPIO 13	34	GND
35	GPIO 19	36	GPIO 16
37	GPIO 26	38	GPIO 20
39	GND	40	GPIO 21

In circuit design (Figure - 2), we're refrencing pins by BCM (Brodcomm SOC channel), and since HC-SR04-ECHO port is rated as 5v, however input pin of GPIO is rated as 3.3v. So, to send 5v signal to input pin, we have to include a voltage divider circuit. Voltage divider is consists of 2 resistors of 1KΩ. and 2KΩ. in series connected to ECHO (V_i) where :

$$V_o = V_i * R_2/(R_1 + R_2)$$

In addition to circuit, web camera is connected to universal serial bus port of raspberry pi, which will be accessible via IP address of server over network.

Table - III states the connectivity of devices' port with particular GPIO location.

C. Area and Device Installation

For circuit (Figure - 3) installation, a space was selected as working area. Since the device is consists of one heat sensor, one ultrasonic ranging device and repeller, space selected was a small area with the size of 10 sq. m.; The device was installed in the corner with sensors facing same side and camera fixed at some height.

D. Data Analysis

After installing and activating the device, scripts which was written in python language is used to identify motion of rodents using heat sensor which provides descrete values. Considering these descrete values as flag signal, URD sensor was activated to calculate the distance of rodent and simultaneously webcam daemon is activated to capture a snap of

TABLE III
GPIO HEADER SENSOR CONNECTION

Device	Port	GPIO Pin
URD Sensor	TRIG	GPIO 23
	ECHO	GPIO 24 with Voltage Divider
	VCC	PIN 2
	GND	PIN 6
PIR Sensor	VCC	PIN 2
	OUT	GPIO 7
	GND	PIN 6
Repeller	VCC	GPIO 4
	GND	PIN 6
Camera		Universal Serial Bus

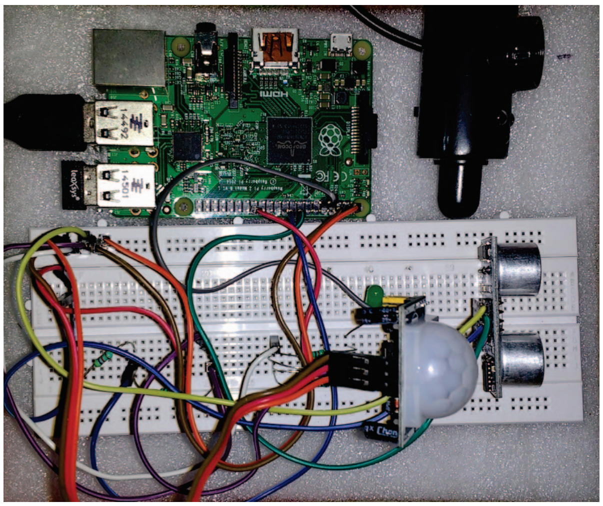

Fig. 3. Screenshot of Prototype

area. Ultrasonic ranging device and web camera is dependent upon the values generated by PIR sensor.

E. Data Transmission

The analyzed data and information is further stored in SQL based database provided by ThingWorx's IoT platform (Figure-4) using cURL command line tool and library through HTTP protocal. Further, a SMS application programming interfeace is used to deliver analyzed information to user including IP address of the server to access webcam daemon.

F. Application

After data processing, on application interface, a website's link will be sent to the user along with timestamp and information, and based upon the distance calculated by ultrasonic ranging device, repeller will be activated with a particular frequency within range (30kHz to 65kHz) which is aversive to rodents.

IV. RESULTS AND DISCUSSION

The proposed smart security system is implemented using Python Programming Language and the devices are controlled

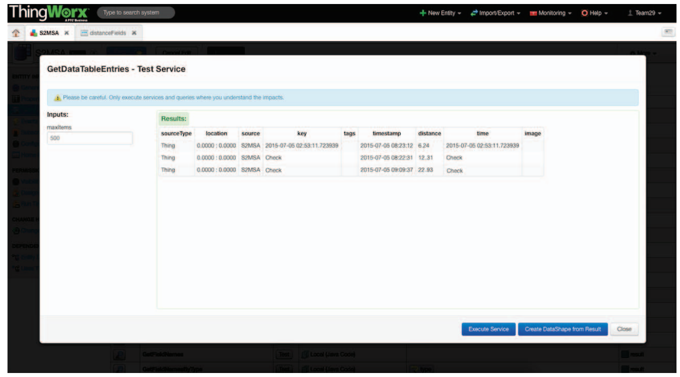

Fig. 4. Screenshot of ThingWorx's Platform Test with S2MSA

using Python scripts and RPi Libraries. After the collection of the data further processing and transmission of the data to ThingWorx IoT platform's server is needed for that a script is written in Python along with API written in cURL is used. ThingWorx is a internet of thing based platform provided by PTC LLC. to provide machine to machine services and internet of thing based application. cURL is a computer software project written in C Language which provides library and command line tool for transferring using it's library "libcurl" which supports common range of protocols including HTTP, HTTPS, FTP, FTPS, TELNET, IMAP, POP3 and SMTP.

A. Algorithm to access functionality of security system

In Algorithm 1, a REST Client is used to connect with RESTful web services of ThingWorx's IoT platform. We're considering the distance between 2 centimeter to 400 cm in one direction. Using wireless sensor network and sensor grids the capability can be increased.

B. USB Camera configuration to access through Raspberry Pi

In our prototype, a basic USB based web camera is used for monitoring purpose along with **Motion** daemon tool and **FSWEBCAM** to capture timelapse images. Following steps were executed in order to configure web camera with Motion:

- Setup 'Motion'
- Configure 'Motion'
  - `'daemon' = ON`
  - `'webcam_localhost' = OFF`
  - `'stream_port' = Default, 8081`
  - `'control_localhost' = OFF`
  - `'control_port' = Default, 8081`
  - `'framerate' = 40`
  - `'start_motion_daemon' = YES`

C. Result Analysis

Table IV represents the value transmitted by security system to database. DistanceMeasured is in centimeters and Time is in "dd-mm-hh:mm:ss" format. After configuring weblink *i.e. 172.16.0.207:8081 for prototype*, the API template is modified

TABLE IV
RECORDS TRANSMITTED TO THINGWORX'S SERVER

This table contains information stored in ThingWorx's SQL Database by smart security system. Date: 04th July - 5th July and 18th December 2015

Sr.No.	Time	Distance	Contact
1	2015-07-04 20:01:23	3.39	919872583672
2	2015-07-04 21:01:23	7.15	919872583672
3	2015-07-04 23:12:05	5.33	919872583672
4	2015-07-05 01:36:22	4.58	919872583672
5	2015-07-05 01:58:34	57.18	919872583672
6	2015-07-05 01:58:58	51.31	919872583672
7	2015-07-05 01:59:38	53.37	919872583672
8	2015-07-05 02:01:31	59.91	919872583672
9	2015-07-05 02:01:31	55.63	919872583672
10	2015-07-05 02:13:40	5.63	918437479642
11	2015-07-05 03:32:52	7.39	918437479642
12	2015-07-05 03:47:06	34.27	918437479642
13	2015-07-05 04:11:25	33.84	918437479642
14	2015-07-05 04:11:41	34.18	918437479642
15	2015-07-05 04:19:12	33.75	918437479642
16	2015-07-05 04:19:26	33.86	918437479642
17	2015-07-05 08:07:45	5.74	918437479642
18	2015-07-05 08:07:54	5.77	918437479642
19	2015-07-05 08:23:08	6.24	918437479642
20	2015-07-05 10:27:17	129.38	918437479642
21	2015-07-05 10:27:31	3.65	918437479642
22	2015-07-05 11:53:47	4.78	919872583672
23	2015-07-05 14:09:46	5.35	919872583672
24	2015-07-05 14:10:05	22.31	919872583672
25	2015-07-05 14:42:59	5.28	919872583672
26	2015-07-05 14:59:45	9.54	919872583672
27	2015-07-05 15:01:49	5.8	919872593672
28	2015-07-05 15:02:14	10.36	919872583672
29	2015-07-05 15:02:38	7.75	919872583672
30	2015-12-18 14:46:00	289.44	919872583672
31	2015-12-18 14:46:03	115.01	919872583672
32	2015-12-18 14:46:04	112.37	919872583672
33	2015-12-18 14:46:05	113.23	919872583672
34	2015-12-18 14:46:08	136.81	919872583672
35	2015-12-18 14:46:09	139.81	919872583672
36	2015-12-18 14:46:13	299.83	919872583672
37	2015-12-18 14:46:14	299.06	919872583672
38	2015-12-18 14:46:18	287.23	919872583672
39	2015-12-18 14:46:19	288.39	919872583672
40	2015-12-18 14:46:30	287.19	919872583672
41	2015-12-18 14:46:31	289.39	919872583672
42	2015-12-18 14:46:32	287.76	919872583672
43	2015-12-18 14:46:40	286.87	919872583672
44	2015-12-18 14:46:41	19.3	919872583672
45	2015-12-18 14:46:42	25.23	919872583672
46	2015-12-18 14:46:45	54.64	919872583672
47	2015-12-18 14:46:46	17.66	919872583672
48	2015-12-18 14:46:47	289.77	919872583672
49	2015-12-18 14:46:50	5.01	919872583672
50	2015-12-18 14:46:51	17.46	919872583672
51	2015-12-18 14:47:01	16.12	919872583672
52	2015-12-18 14:47:02	20.58	919872583672
53	2015-12-18 14:47:06	4.19	919872583672
54	2015-12-18 14:47:07	17.66	919872583672
55	2015-12-18 14:47:29	287.78	919872583672
56	2015-12-18 14:47:51	298.29	919872583672
57	2015-12-18 14:47:53	9.54	919872583672
58	2015-12-18 14:48:06	9.96	919872583672
59	2015-12-18 14:48:07	10.0	919872583672
60	2015-12-18 14:48:29	9.57	919872583672
61	2015-12-18 14:48:30	8.71	919872583672
62	2015-12-18 14:48:51	11.61	919872583672
63	2015-12-18 14:48:52	10.01	919872583672
64	2015-12-18 14:49:00	6.93	919872583672
65	2015-12-18 14:49:03	298.67	919872583672
66	2015-12-18 14:49:06	297.71	919872583672
67	2015-12-18 14:49:07	300.72	919872583672
68	2015-12-18 14:49:26	299.4	919872583672
69	2015-12-18 14:49:27	6.19	919872583672
70	2015-12-18 14:49:51	9.96	919872583672

Algorithm 1 Algorithm to Control Security System

▷ % RPi.GPIO is imported as GPIO and GPIO mode is set as BCM Mode%
PIRPIN = 7
TRIG = 23
ECHO = 24
while (true) **do**
  Set GPIO.IN as PIRPIN
  if (GPIO.input(PIRPIN)) **then**
    Set GPIO.OUT as TRIG
    Set GPIO.IN as ECHO
  ▷ %Below mentioned 3 steps are used to initialize the URD Sensor%
    Set TRIG output to FALSE for 2ms
    Set TRIG output to TRUE for 0.01ms
    Set TRIG output to FALSE
    while (GPIO.input(ECHO)==0) **do**
      pulseStart = time.time()
    end while
    while (GPIO.input(ECHO)==1) **do**
      pulseEnd = time.time()
    end while
    pulseDuration = pulseEnd - pulseStart
    distance = pulseDuration * 17150
    distance = round(distance, 2)
    if (distance >2 and distance <400) **then**
      ▷ %Save Information into Database%
      Initialize subprocess as (fswebcam -r $date.jpg)
      Initialize REST API
      $content = ’”DistanceMeasured”:”’+ str(distance)+ ’”,”Time”:”’+str(datetime.datetime.now())+’”’
      Post $content to database using cURL
      Set GPIO Output to GPIO PIN 4
      ▷ %Turn on Pest Repeller%
      GPIO.output(4, true)
      ▷ % Wait%
      time.sleep(min)
      GPIO.output(4, false)
    end if
  end if
  GPIO.cleanup()
end while

later to provide webcam access link within the body of user notification text.

In the represented sample data, 70 time periods are shown to denote the test object's distance after each detectation. As the object is detected at 7.15cm, electronic pest repeller is activated for few seconds. Based on successful data retrieval and transmission, we were able to achieve success in 84.8% i.e. 118 test cases out of 139 test cases.

Unsuccessful test cases i.e. 15.2% were due to device's connectivity, data transmission, notification and other factors such as PIR sensors are configured to generate discrete values, so the device is also able to generate record if it founds any human near heat sensor.

V. Conclusion and Future Scope

'Internet of things' is widely used in connecting devices and collecting information. The system is designed for identification of rodents in grain stores. After collecting and analyzing the data, algorithm is designed to provide accuracy in notiifying user and activation of repeller. All the results are calculated by taking several readings. The testing is done in an area of 10 sq.m. with device placed at the corner. Once PIR sensor identifies heat it starts URD sensor and webcam, along with it, device sends random number of notifications (based upon timestamp) to user.

For future upgradation, device will inherit a grid of sensor panels consisting PIR sensors and URD sensors. The device can incorporate pattern recognition techniques for machine learning and to identify objects and categorize them into humans, rodents and mammals, also sensor fusion can be done to increase the functionality of device. Improving these perspectives of device, it can be used in different areas. This project can undergo for further research to improve the functionality of device and it's applicable areas. We have opted to implement this system as a security solution in agricultural sector i.e. farms, cold stores and grain stores.

The results of the work point to the following directions of research that are likely to be needed for further improvement.

- It may be helpful to extend the security system to prevent rodents in grain stores.
- It can be further improved for the identification and categorization between humans, mammals and rodents.
- Device can be enabled to collect more information about surroundings and presence of threats so that implementation of machine learning is achieved.
- Location of device in area can also be change based upon the location of grains for more effective results.

References

[1] Nikkila, R., Seilonen, I., Koskinen, K. 2010. ''*Software Architecture for Farm Management Information Systems in Precision Agriculture.*'' Comput. Electron. Agric. 70 (2), 328-336.

[2] Alexandros Kaloxylos, J Wolfert, Tim Verwaart, Carlos Maestre Terol, Christopher Brewster, Robbert Robbemond and Harald Sundmaker. ''*The Use of Future Internet Technologies in the Agriculture and Food Sectors: Integrating the Supply Chain*'' in 6th International Conference on Information and Communication Technologies in Agriculture, Food and Environment. pp. 51-60

[3] Kevin Ashton, ''*That Internet of Things thing*'' RFID Journal, It can be accessed at : *http://www.rfidjournal.com/articles/view?4986*

[4] D. Singh, G. Tripathi, A.J. Jara, ''*A survey of Internet-of Things: Future Vision, Architecture, Challenges and Services* in Internet of Things (WF-IoT), 2014

[5] ''*Gartner, Inc.* '' It can be accessed at: *http://www.gartner.com/newsroom/id/2905717*.

[6] Malik Tubaishat, Sanjay Kumar Madria ''*Sensor networks: An Overview*'', IEEE Potentials 05/2003.

[7] Juan Felipe Corso Arias., Yeison Julian Camargo Barajas., Juan Leonardo Ramirez Lopez., ''*Wireless Sensor System According to the Concept of Internet of Things*'', International Journal of Advanced Computer Science and Information Technology Volume 3, Issue 3, 2014, ISSN: 2296-1739

[8] Tadele Tefera, Fred Kanampiu, Hugo De Groote, Jon Hellin, Stephen Mugo, Simon Kimenju, Yoseph Beyene, Prasanna M. Boddupalli, Bekele Shiferaw, Marianne Banziger. ''*The Metal Silo: An effective grain storage technology for reducing post-harvest insect and pathogen losses in maize while improving smallholder farmers' food security in developing countries*'', The International Maize and Wheat Improvement Center (CIMMYT), Volume 30, Issue 3, March 2011.

[9] Grant R. Singleton. '' *Impacts of rodents on rice production in Asia.*'' IRRI Discussion Paper Series No. 45, 30 pp. (International Rice Research Institute: Los Banos, Philippines.)

[10] Fan TongKe., ''*Smart Agriculture Based on Cloud Computing and IOT*'', Journal of Convergence Information Technology(JCIT) Volume 8, Number 2, Jan 2013.

[11] Sugam Sharma, U S Tim, Shashi Gadia, and Johnny Wong.(2015). ''*Growing Cloud Density and as-a-Service Modality and OTH-Cloud Classification in IOT Era*'' Available at www.public.iastate.edu/ sugamsha/articles/OTH-Cloud/in/IoT.pdf

[12] Sugam Sharma. (2015). ''*Evolution of as-a-Service Era in Cloud*'' Cornell University Library. Available at arxiv.org/ftp/arxiv/papers/1507/1507.00939.pdf

[13] Chun-Wei Tsai, Chin-Feng Lai, Athanasios V. Vasilakos., ''*Future Internet of Things: open issues and challenges*'', Wireless Netw (2014) 20:2201–2217, Springer Science + Business Media New York 2014.

[14] M.U. Farooq, Muhammad Waseem, Anjum Khairi, Sadia Mazhar., '' *A Critical Analysis on the Security Concerns of Internet of Things (IoT)*'', International Journal of Computer Applications (0975 8887) Volume 111 - No. 7, February 2015.

[15] Rafiullah Khan, Sarmad Ullah Khan, R. Zaheer, S. Khan, ''*Future Internet: The Internet of Things Architecture, Possible Applications and Key Challenges*, in 10th International Con- ference on Frontiers of Information Technology (FIT 2012), 2012, pp. 257-260