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Use of Smart Sensor &IoT to Monitor the Preservation of Food Grains at Warehouse

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***Abstract*—India is one of the largest agricultural land in the world with approximately 179.9 million hectares under cultivation. Still in India, food grains are stored at warehouse using traditional technology which leads to problems such as theft, rain, flood, variation in temperature and humidity, attacks of rodents, insects etc. In this paper we integrate smart sensing devices with Internet of Things (IOT) and Wireless Sensor Networks to preserve the quality and quantity of the stored products over time. This device can be controlled and monitored from remote location and delivering real time notification based on information analysis and processing without human intervention.**

***Keywords*—Internet of things (IoT), Agriculture, Security, Raspberry Pi, Sensors, Wireless Sensor Network (WSN).**

I. INTRODUCTION

Agriculture sector being the backbone of the Indian economy deserves food security. Today, food preservation is very important to fulfill the food supply chain needed by the developing countries like India. There is a huge need for preservation, protection, storage, distribution and consumption of food at later stage. The main objective of this project is to preserve the food grains from rodents invading at warehouses and also threat to destruction of stored crops, due to variation in temperature, excess humidity, fire, theft, rain, flood, etc. So that stored food grains can be delivered as and when required (real time).In this paper we are integrating Internet of Things with smart sensors to improve the efficiency of food preservation in warehouse.

Fig-1. Food grains stored at warehouses in India

During storage, quantity as well as quality of food grains will be decreased due to insects, rodents, insects and micro-organisms.Almost all species have remarkably high rates of multiplication and, within one season, may destroy 10-15% of the grain and contaminate the rest with undesirable odors and flavors. Insect pests also play a pivotal role in transportation of storage fungi.

Over the past years, IOT and WSN technology have been introduced in agriculture for improving the efficiency of food production and transportation, but these technologies are not yet used for food security purpose stored at warehouse. The significant challenge facing the food security at warehouse is the interaction between the Security devices and to provide them intelligence to control other electronic devices such as cameras, repellers etc to enhance the efficiency of food security at various warehouses.

II. INFLUENCES OF ENVIRONMENTAL FACTORS ON FOOD GRAINS IN WAREHOUSE

Degradation of grains during storage depends principally on a combination of three factors:

1. Temperature.
2. Moisture.
3. Oxygen content.

Temperature and moisture are determining factors in accelerating or delaying the complex phenomena of the biochemical transformation (especially the "breathing" of the grain)that are at the origin of grain degradation. Furthermore, they have a direct influence on the speed of development of insects and microorganisms (moulds, yeasts and bacteria), and on the premature and unseasonal germination of grain. The temperature depends not only on climatic conditions but also on the biochemical changes that are produced inside a grain mass, provoking undesirable natural heating of the stored products. As for the moisture content of the stored grain, it depends on the relative humidity of the air. With relative air humidity below 65-70percent, many grain-degradation phenomena are slowed down, if not completely blocked. During storage, moisture within the product reaches an equilibrium with the air within and between the product particles and produces a relative humidity level that may be suitable for the growth and development of deteriorative organisms.

GRAIN	MOISTURE
Paddy	14.0%
Rice	13.0%
Maize	13.0%
Wheat	13.0%
Groundnut	7.0 %

Table-1 Moisture threshold values for different grains.

Oxygen content: Like grain, micro-organisms and insects are living organisms that need oxygen. Storage of grain in places that are low in oxygen causes the death of insects, cessation of development of micro-organisms, and blockage, or slowing down, of the biochemical phenomena of grain degradation. This favours the conservation of grain, but may affect its germinating power.

III. Agents causing deterioration of stored grain

The principal enemies of stored grain are

1. Micro-organisms.
2. Insects and
3. Rodents.

1) Micro-organisms: Micro-organisms (moulds, yeasts, bacteria) are biological agents present in the soil which, when transported by air or water, can contaminate products. Their presence and growth cause severe changes in the nutritive value and the organoleptic features of grain (taste, smell).
Cracked or broken grain foster the development of micro-organisms. Futhermore
Temperature and humidity have a determining influence on the growth rate of these degradation agents.It has beenobserved that micro-organisms develop at temperatures between -8°C and +80°C, when the relative humidity of the air is over 65 percent.

2) Insects: More than 60 species of insects can occur in stored grain and grain productsInsect infestations can occur either in the field, before the harvest, or in the places where products are stored.In some cases, these infestations are difficult to discern with the naked eye, since the damage is provoked by the larvae developing inside the grain.The insects most likely to infest stored products belong to the following families:

- Coleoptera (damage by larvae and adult insects);
- Lepidoptera (damage only by larvae).

Insects can be responsible for significant losses of product. Furthermore, their biological activity (waste production, respiration, etc.) compromises the quality and commercial value of the stored grain.

3) Rodents : Rodents invade and multiply in or near storage places, where they can find an abundance of food. They cause serious damage not only to stored products but also to the storage buildings.They gnaw to reach previously inaccessible areas which can cause considerable damages to your family, ruin your stock and expose wires which can become a serious fire hazard. Around 5 to 10% loss of crops due to rodents like grain contamination is the main risk from rodents infestation.

The principal rodents, those most common and likely to attack stored products, belong to the following species:

- Black rat, also called roof rat (Rattusrattus).
- Brown or Norway rat, also called sewer rat (Rattusnorvegicus), mouse (Mus musculus).

This contamination is as important from the marketing standpoint as it is for hygiene and health. Indeed, rodents are often the vectors of serious diseases (rabies, leptospirosis).

Enzymes: Enzymes are specialized proteins of living matter that catalyze, or speed up, chemical reactions. Freshly harvested seeds entering the bin are often immature and may have increased enzymatic activity, resulting in high respiration rates and in heat production. High seed moistures and green weed seeds and debris also favor increased enzymatic activity. During this early storage period, carefully monitor the stored commodity.

IV. SAFE STORAGE GUIDELINES

Moisture content and temperature determine
the safe storage period for any grain or oilseed. The canola/rapeseed storage time chart (Fig. 2) predicts the keeping quality of canola/rapeseed over 5 months, under varying temperatures and moistures. If the temperature or moisture content of canola/ rapeseed falls within the spoilage area of the chart, take steps to reduce one factor or both. To reduce the moisture content, either delay combining to allow further drying in the swath or artificially dry the seed. To reduce the seed temperature, aerate the bin

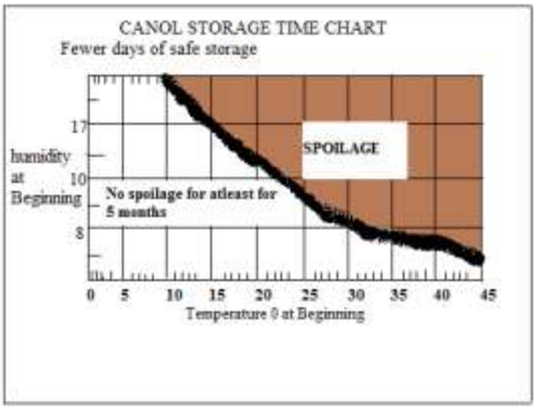

Fig-2 Canola/rapeseed storage time chart based on seed moisture and temperature at beginning.

V. REVIEW OF LITERATURE

Appropriate storage technology has been the major problem of Indian agriculture for a very long time. Most of the warehouses are not guarded, moisture proof, rodent proof and are not air tight. Cameras may be installed to enhance security but it cannot be of use until recorded media is accessed. Cost is also a major factor.

At present, there is no complete solution which can provide security for food grains. There is lack of appropriate technology like there is no proper security, moisture proof or rodent proof in most of the warehouses.

A study once represented that a quantity of wheat equivalent to the entire production of Australia goes to waste each year in India. Rupees 44,000 crore is the value of food grains wasted in India every year. What’s more, the food grain wastage value is 150 per cent of India’s budget allocation on agriculture.

The problem of food wastage is not new. Food Corporation of India has admitted of food grain wastage of 79 million tonnes between 2009 and 2013. India produces about 260 million tonnes of food grain every year including wheat, rice, pulses and cereals. Rice has the major share (105 million tonnes), in it, followed by wheat (95 million tonnes), cereals (42 million tonnes) and pulses of (18 million tonnes). Farmers them-selves store about 70 per cent of the produce on their own and 30 per cent is procured by the government through different schemes for storage and public distribution. While the storage by farmers suffers the wastage of 6 per cent due to rodents, insects and fungi, surprisingly the wastage is about 30 per cent when the food grain is stored by FCI and state warehouses. It is surprising that the highest wastage occurs in the so-called developed states of Gujarat, West Bengal, Punjab, Maharashtra and Uttarakhand.

VI. RESEARCH METHODOLOGY

In the proposed scenario, lack of information transmission and data analyzing can be solved by the integration of IOT.The sensory information areanalyzed in order to activate electronic devices and raspberry pi is used as a server to analyze data and transmit information to user. Neither traps nor poisons provide a long term solution. Rodents simply increase breading to replace rodents lost to poisons or traps. It's an unending cycle. Ultrasonic sound repeller emphasizes non toxic prevention of rodents rather than elimination.

VII. SYSTEM REQUIREMENTS

A. Hardware Requirements

Processor	:	Pentium 4 +
RAM	:	2GB
Hard Disk	:	20GB
Speed	:	1.2 GHz+

Components used:

1) Raspberry Pi 3 Model B+
2) Sensors (PIR,Temperature and Fire)
3) Ultrasonic Ranging Device
4) Web Camera
5) Buzzer

B. Software Requirements

1) Java.
2) Win forms using c #. Net.
3) Android studio.

VIII. SYSTEM ARCHITECTURE

A. Architecture

Device uses 3 interface for data collection, analysis andtransmission. IoT architecture is categorized in 3 level architectureand five level architecture. Figure-3 shows the workingphenomena of device based upon 3 level 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 theinformation over network.

• Application layer : This layer is responsible for various

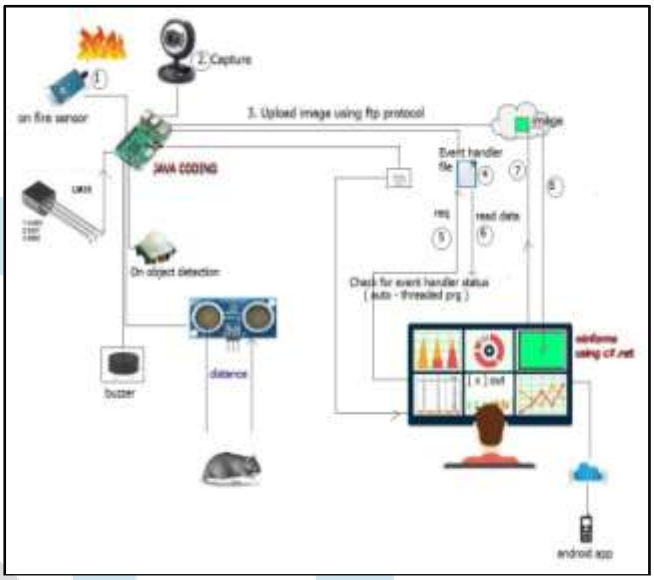

Fig-3.system architecture.

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B. DATA ANALYSIS

Once all the devices are installed and activated, we run our Java scripts, that enables us to identify motions of rodents if any using heat sensors that outputs discrete values. These discrete values are used to flag signals to activate URD sensors.URD sensor are used to calculate the distance of rodent and simultaneously, webcam daemon is activated further to capture a snap of the same area. Accuracy of ultrasonic ranging device and web camera is dependent upon the values generated by PIR sensor.

C. DATA TRANSMISSION

The analyzed data and information is further stored in SQL based database provided by ThingWorx'sIoT platform 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.

D.CURCUIT DESIGN

The sensors and camera is connected to GPIO header. PIR sensor has three pins as VCC, OUT and GND, while ultrasonic ranging device(HCSR04)contains four pins as TRIG,ECHO, VCC and GND. Device also contains a ultrasonic sound basedrodent repeller which will be activated by server based upon data analysis.The fig-4 shows the snapshot of the proposed prototype.

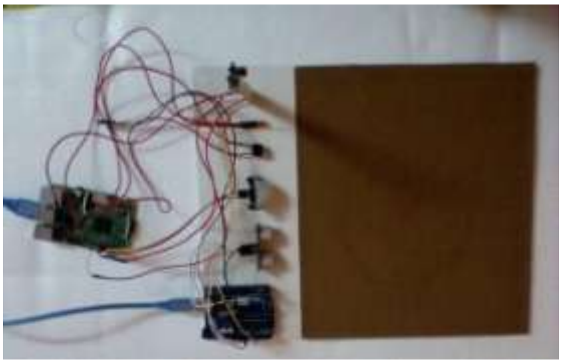


Fig-4 Screenshot of prototype

Raspberry Pi 3 Model B+ is third generation model maintains the same popular board format as the Raspberry Pi 2 and Raspberry Pi B+, but boasts a faster 1.2GHz ,64Bit SoC, and on board Wi-Fi and Bluetooth.

Table 2. GPIO Header Pin Out Of Raspberry Pi3

PIN GPIO	**PIN GPIO**
1 3.3VDC	2 5VDC
3 GPIO 8	4 5VDC
5 GPIO 9	6 GND
7 GPIO 7	8GPIO 15
9 GND	10 GPIO 16
11 GPIO 0	12 GPIO 1
13GPIO 2	14 GND
15GPIO 3	16 GPIO 4
17 3.3VDC	18 GPIO 5
19GPIO 12	20 GND
21GPIO 13	22 GPIO 6
23GPIO 14	24 GPIO 10
25 GND	26 GPIO 11
27 ID EEPROM	28ID EEPROM
29 GPIO 21	30 GND
31 GPIO 22	32 GPIO 26
33 GPIO 23	34GND
35 GPIO 24	36 GPIO 27
37 GPIO 25	38 GPIO 28
39 GND	40 GPIO 29

IX. APPLICATION

Upon completion of data processing, the website's link will be invoked via application interface and sent to the user along with timestamp and information processed. Simultaneously, the repeller will be activated based upon the distance calculated by ultrasonic ranging device working at frequency ranging from 30 kHz to 65 kHz that resulting in causing aversiveness to rodents.

X. RESULTS AND SNAPSHOTS

The sensors, camera, Led light and buzzer are connected to the Raspberry Pi device. When the motion of the object or fire flame is detected Led light and buzzer turns on. Ultrasonic ranging device detects the distance of the object. Passive Infrared sensor detects the motion of the object. Arduino Uno acts like a bride between URD and Raspberry Pi device. Web camera is used to capture the image of the object or image of the fire flame. Raspberry pi uploads the captured image and information to the cloud. From the cloud notification is send to user.

Table 3. warehouse Information stored in sql database.

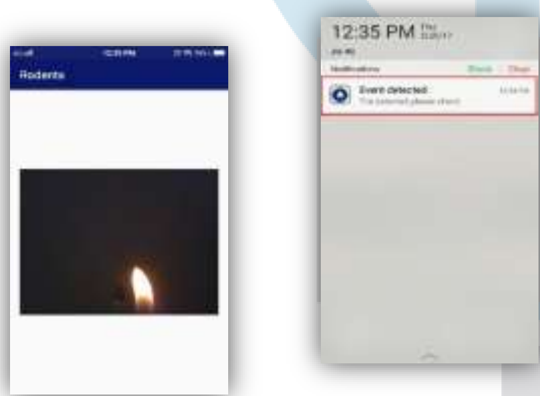
id	link		sensor	
2237	264201763648.png	16B	m	1B
2238	noimage.png	11B	28.65	5B
2239	26420176400.png	15B	m	1B
2240	26420176408.png	15B	m	1B
2241	264201764037.png	16B	m	1B
2242	264201764054.png	16B	m	1B
2243	26420176413.png	15B	m	1B
2244	264201764120.png	16B	m	1B
2245	264201764129.png	16B	m	1B
2246	26420176421.png	15B	f	1B
2247	264201764247.png	16B	m	1B
2248	264201764343.png	16B	f	1B
2249	264201764353.png	16B	m	1B
2250	noimage.png	11B	28.24	5B
2251	noimage.png	11B	28.56	5B
2252	noimage.png	11B	28.81	5B
2253	264201773051.png	16B	f	1B
2254	26420177315.png	15B	m	1B
2255	264201773112.png	16B	m	1B
2256	264201773142.png	16B	f	1B
2257	264201773149.png	16B	m	1B
2258	noimage.png	11B	28.81	5B
2259	264201773241.png	16B	m	1B
2260	264201773249.png	16B	m	1B
2261	264201773444.png	16B	m	1B
2262	264201773557.png	16B	m	1B
2263	264201773755.png	16B	m	1B
2264	264201773812.png	16B	m	1B
2265	264201773823.png	16B	m	1B
2266	264201773832.png	16B	m	1B
2267	264201774025.png	16B	m	1B
2268	noimage.png	11B	29.3	4B
2269	noimage.png	11B	29.3	4B
2270	noimage.png	11B	29.54	5B
2271	noimage.png	11B	27.26	5B
2272	294201743856.png	16B	m	1B
2273	29420174394.png	15B	m	1B
2274	noimage.png	11B	27.34	5B
2275	294201744154.png	16B	m	1B
2276	noimage.png	11B	30.52	5B
2277	294201744311.png	16B	m	1B
2278	294201744358.png	16B	f	1B
2279	294201744416.png	16B	m	1B
2280	noimage.png	11B	27.83	5B
2281	294201744456.png	16B	m	1B
2282	noimage.png	11B	27.83	5B
(NULL)	(NULL)	0K	(NULL)	0K

Table 3 contains id, link and sensorinformation stored at database. In the link column link of the captured image is present with its date of captured. For temperature, no image will be displayed. The sensor column contains the type of the event sensed.

(a) (b)
Fig-5 snapshots of Monitoring screen

When the PIR sensor detects the motion of the object, a notification is displayed as “motion detected!!” on the display screen(fig-5 a).Similarly, when the presence of fire flame is detected by the fire sensor in the warehouse, again the red colour in the monitor page turns to green with a notification “fire detected!!”(Fig-5 b).

Fig-6 snapshot of notification to the Desktop User



(a) (b)
Fig-7 snapshots of mobile notification

This page displays motion detected notification along with captured image of the object on the screen when motion detected at warehouse as in the fig-6.
Similarly,fire detected notification along with captured image of the fire flame on the screen is displayed when fire is detected at warehouse. If the desk top user selects out of desk option then same notifications along with image is send to the registered mobile as shown in the fig-7.
And also, the temperature variation notification when the temperature crosses the threshold value is displayed. By seeing these notifications user can take an appropriate action.This page displays temperature variation notification when the temperature crosses the threshold value. By seeing these notifications user can take an appropriate action.

XI. CONCLUSION AND FUTURE SCOPE

’Internet of things’ is widely used in connecting devices and collecting information. The system is designed for identification of rodents, variation in temperature, fire detection, motion detection at warehouse. After collecting and analysing the data, algorithm is designed to provide accuracy in notifying user and activation of repeller, buzzer and LED light. 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.
The results of the work point to the following directions of research that is likely to be needed for further improvement

- 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.
- Further enhancement would be that, if the temperature goes beyond the threshold value then the device should automatically turn on the air conditioner or adjust the values of air conditioner.
- We can connect more sensors to our device like vibration sensor, moisture, humidity sensor etc
- When fire has been detected automatically the fire extinguisher should turn on.

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 its applicable areas.

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