International Journal of Aquatic Science
ISSN: 2008-8019
Vol 12, Issue 02, 2021

Digital Farming: IoT Enabled Smart Sensor Based Insect and Animal Detection System

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Abstract: It has been widely observed that production of any crop depends upon the various factors like rain, temperature, soil moisture, humidity, solar radiation atmospheric gases and wing velocity. Apart from these there are various other factors that directly or indirectly influence the crop production like proportion of fertilizers get utilized, parasites, crop diseases, and insects etc. It is globally accepted that these influencing factors are responsible to reduce the total crop yields by 10% to 40%. Various IoT based tools and techniques are frequently being used to increase the crop production. This research work is intended to propose an Internet of Things based insect and animal detection system using smart sensor. The system is based on sensors enabled Arduino UNO Kit to detect the insects and mammals in the farm / crop field. The data is then sent to server via GPRS module to ThingSpeak server for analysis. This analyzed data is then being compared with threshold value and result is forwarded to farmer's mobile, accordingly the farmer can take the precautionary measures.

Keywords : IoT (Internet of Things), ThingSpeak server, Arduino UNO Kit, Actuator.

1. INTRODUCTION

The era of smart agriculture or we can say digital farming has been started by using Internet of Things (IoT). Great innovations in the field of agriculture have been observed by holistic utilization of intelligent sensors based and IoT enabled technologies[1]. IoT based systems[2] are drastically influencing all the agriculture related activities like precise irrigation, cultivation control, information transmission, agricultural product safety, and many more. Also these systems are able to control and manage the key elements related with farming[3] like water management, soil management, farm equipments, crop quality, real time control and related analytics. Digitalization of agricultural activities are now taking the shape , mores specifically we can say era of digital farming is on the board with visible impact. The common IoT based applications in agriculture[4, 5] are:

i) Sensor enabled systems for proper monitoring of soil, crop, livestock, fields, storage facilitiesand other factors influencing the production.
ii) Computerized agricultural electronic equipments like vehicles, drones systems, actuators androbots.
iii) Interconnected agricultural lands like smart green-houses, hydroponics.
iv) Agri-business and management systems, visualization and agricultural data analytics.

v) Agricultural planning and predictive modeling and many more.

In this research work, we have identified the potential application of IoT based system in agriculture domain for the sustainable rural development[6] with the digital farming; And smart sensor based architecture is framed with digital technologies to meet these agricultural challenges.

A sensor based system[2] was developed to detect the crop conditions and the farm conditions. The sensors will brings the data from the farm and it send to the server through the GPRS module, where the data is analyzed and get communicated to farmers using mobile phone. In other words, farmers will get intimated well in advance during the growth stages of crops.

Such digital farming using IoT system is fully based on Arduino UNO Kit, that consists of variety of connected sensors mainly moisture, temperature and humidity sensors, water level sensor, low power image sensor , acoustic sensor , IR sensor , UV sensor. As these device are earlier used by placing them in the farm to check the moisture level, water level and humidity in the soil. Whereas, low power image sensor, acoustic sensor, IR sensor, UV sensor and sound sensors are now used to detect the insects and mammals. These sensors are well in use to monitor insects on leaf, flower crops etc. After sensing all the data sensors sent them to an Arduino UNO kit, then Arduino sent these data to ThingSpeak server for analyzing. The data is sent to server via GPRS module[7] and will be available online and via SMS to farmer. Early detection of probable threat and weather conditions will keep the farm safe and secure.

Since IoT enabled applications[6] are deployed in fields and helps the farmers to acquire critical information, the quality of their produce will improve. Many land owners must recognize the potential of IoT for farming by incorporating smart innovation to boost yield. If the user can successfully employ IoT technology, the requirement for increased population can be met. The solution to assessing digitals agriculture has been demonstrated in this paper.

2. LITERATURE REVIEW

In [8] Jin S. et. al, "A Remote Measurement and Control System for Greenhouse Based on GSM-SMS", A control system that is based on GSM enabled SMS used to represent the measures of remote green house. Which is efficiently able to conquer the problem of unnecessary examination in wire transmission net of large green house groups and its related hassle maintenance.

Yue L. et al[9], "Prediction of Soil Moisture based on Extreme Learning Machine for an Apple Orchard", discussed the IoT architecture of intelligent system used to capture the data from the sensors and gathered data is stored on cloud with live streaming for its analysis, visualization and aggregation.

In [10] Divya J. et. al, "IoT based Smart Soil Monitoring System for Agricultural Production" shows the use of ICT for rural development in agriculture domain. Purpose of project is to deploy automated embedded soil monitoring system in irrigation. The related information will get received on the mobile phones to reduced manual monitoring of the fields. The proposed system will help the farmers to get increase crops production and their agricultural income.

N. Gondchawar and R.S. Kawitkar[2] "IoT based Smart Agriculture", discusses the utilization of sensors for the better farming, and providing the benefits related.

C. Bettstetter [11], GSM and GPRS protocols, architecture and air interface. To provide improved and simplified wireless access services to packet data networks. User's data packets are transferred between external data packet networks and mobile station by applying a packet radio principle. Basic functionality of this system architecture to elaborate the services offered, mobility management, the routing and the session, GPRS protocol architecture including channel coding of GPRS air interface.

M. Mahbub, 2020. IoT, Wireless Sensor Network and embedded electronics based smart agriculture concepts[12]. The paper describes distance based monitoring system to monitor the proper utilization of adequate water , pesticides and fertilizers to ensure the better crop yields , better food production with smart and better farming.

S .D., P., Abuj, M., Tambe, M., &Sangale, M. [13]; Automation in Agriculture System using GSM., designed and developed a adequate framework for water system used in horticulture application. The programmed system used to detect the water level in the tank and dirt dampness of substances and switches the engine ON/OF remotely. System is enabled with GSM modem to intimate status of engine is through SMS. The related advantage of this technique is a genuine water system with less human intervention.

Saikumar C. V. et al.[14] "IoT Based Air Quality Monitoring System" in IJPAM, Project provides wireless communication technology based monitoring system to monitor eminence of air in urban and industrial areas. Project provides systems with the use of low rate, low information rate based real time monitoring system.

Ms. Shraddha and and K. M Ashok.[15], "IOT Based Agriculture"; Designed and developed E- system for irrigation purposes. The system is based on real time monitoring and controlling of field variables using software controlled sensors using wireless sensor network. Base station receives the field data from the sensor station units deployed in the farm to capture and collect the data.Where the base station is GPS enabled and responsible to takes all necessary action required in order to controls the irrigation activities with available database.

In [16]Sushanth and Sujatha G., "IoT Based Smart Agriculture System"; The paper reflects the utilization of evolutionary and automation technologies used for smart agriculture like IoT. Sensors are installed in the crop field to supervise the factors responsible for yield of crops. The Arduino based system developed that is used to supervise the moisture, humidity, temperature and the intrusion of animals in the crops.

3. PROPOSED SYSTEM

The proposed system (figure 1) contains mainly hardware components (sensors) and GPRS module with ThingSpeak server. Overall five sensors are get installed in this system; including DHT11 sensor for humidity and temperature measurement; ultrasonic, IR and sound detection sensors for insect and mammal detection; for water level measurement soil-moisture sensor. All these sensors are connected with Arduiono UNO kit and with GPRS module[7] using wire. The Arduino UNO microcontroller gets installed on a computer. ThingSpeak server is installed on the computer through which the Ardiuno UNO is connected. The data reading captured by these sensors get transmitted to Arduino kit where it may be displayed in the IDE of Arduino. A GPRS enabled messaging services is connected with Arduino UNO kit to facilitate in sending the SMS to the farmer regarding current intrusion of insects and mammals in the area.

[A] Hardware Components

Five different type of sensors are being used for the purpose.

(a) Ultra Sonic Sensor: Ultra sonic sensor is used to detect small animals in farm and it also detect the distance of insects or small animals. This sensor is also used to detect the harmful creatures like rats, rabbits etc; which are responsible to destroy the crops.

(b) Sound Detection Sensor: Most of the pests generates the sound while flying, mating or chewing the plant leaves, sound sensor is then used to pick up these generated sound from the surrounding environment of the crop. Sound sensor records data of noise levels at particular place for specific period of time. This recorded data is then analyzed on computer system using tools to generate useful information for the farmers. Such sensors are very useful to detect grasshopper, rootborer, thrips and bollworm etc .

(c) IR Sensor: In this project for monitoring big animals we use IR Sensor. This sensor gives acknowledgment to entering animal in farm. Animals like cow, goat, wild cow, buffalos often found hidden in the mid of the crop field, IR sensors are able to detect such animals with high accuracy and probability. In some of the cases it was found that use of infrared technology is harmful in direct sunlight. Under those circumstances utilization of some other sensors working with different principle are precisely recommended in respect of infrared technology based sensor. So we can say this sensor is very useful to detect goat, bull or any large animal which destroy farm heavily.

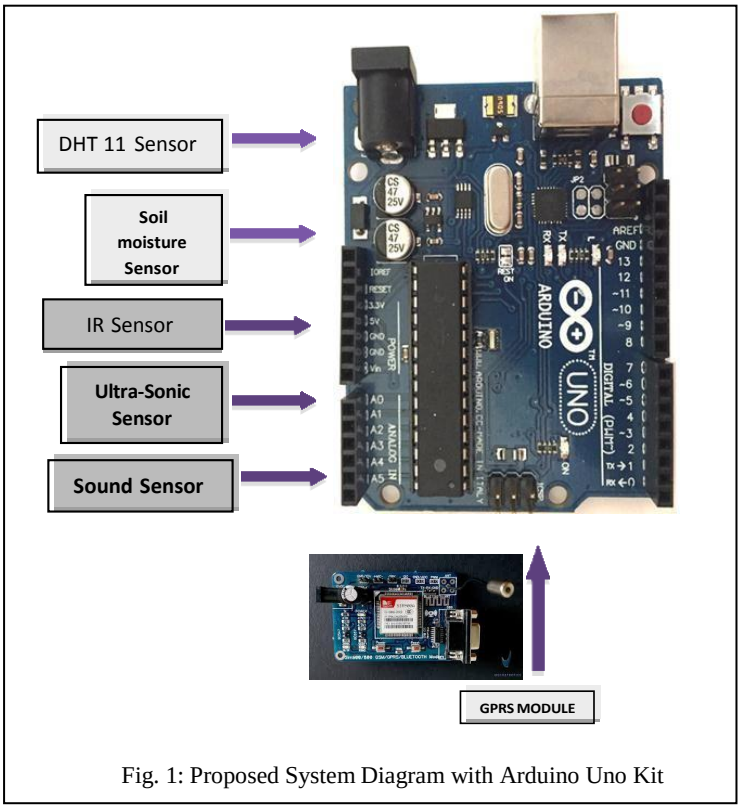

Fig. 1: Proposed System Diagram with Arduino Uno Kit

(d) Temperature and Humidity Sensor: DHT11 sensor is frequently used a very basic, small in size and ultra low cost digital device for measurement of temperature and humidity. This sensor is interfaced with microcontroller Arduino kit board and gives output in digital signals form. DHT11 contains a thermistor / NCT component for temperature measurement with range from 0^{o}C to 50^{o}C; and a capacitive / resistive type humidity sensing element with 5% accuracy in between the 20% to 80% with and sampling rate of 1Hz; it means sensor is able to capture one reading per second.

(e) Soil-Moisture Sensor: Soil-moisture sensor is used to measure the volumetric content of water within the soil in open field and in green houses. Sensor is connected to the Arduino kit in digital mode. Sensor soil moisture value is measured by Arduino analog PIN and it is converted into Analog to Digital(ADC). Normally the ADC value for a farm varies between 300 to 500. Here, potentiometer is important component of this soil sensor unit works as sensitivity adjuster of the Digital Output (DO), also used to fix the threshold value. Captured data value (signal) by the sensor get produced as output voltage at Analog Output(AO) PIN depending on the resistance. The signal is then digitalize by comparator at Digital Output (DO) PIN.

[B] GPRS Module and ThingSpeak Server: A dedicated GSM modem device with bluetooth connection or with a serial, USB, or it can be a cellular telecell smart phone with GSM modem functionality. Nominal charges were being imposed by cellular operator for sending and receiving messages as if they were sent and received instantly on a cellular telecell smart phone. A GSM modem should assist a "prolonged AT command" in carrying out those functions. A GSM modem should assist a "extended AT command set" to send/receive messages (SMS) in carrying out such functions. Because a unique subscription to an SMS service firm is not usually necessary, To start the SMS facilities a GSM modems can be a speedy and green method where the sender is responsible for message delivery. And this modem will tends to provide purely cost effective solution which is acceptable word wide. A preferred GSM cellular telecell smart phone having the greatest cable and software programme motive force to connect with a serial/ USB port of computer is a GSM modem. ThingSpeak server is open source software used as IoT analytics platform for analyzing, visualizing and aggregation of data. ThingSpeak server is privileged with data collection and live data streaming od data in the cloud. ThingSpeak server able to create instant visualization of live data received from sensor device and send the SMS. ThingSpeak server provides the facilities of advance data analysis with build- in tool MATLAB.

4. METHODOLOGY

The sensors (DHT11,Soil-moisture, IR, Ultrasonic and Sound) are deployed in the field in connection with Arduino UNO microcontroller already installed on computer . Sensors are initialized by coding through Arduino system software (IDE) which will work as a simulator. Threshold values of sensors will be programmed and defined as (0,1) for IR sensor; 100cm for Ultrasonic Sensor , 200Hz for Sound Sensor, 30^{o}C for DHT11 Temperature Sensor and for Humidity 70% in the ranges from 300 to 500. If the readings of sensors are greater than the threshold values then this captured data values are transmitted[7] to the Anduino for display on Arduino (IDE). Simultaneously a messaging service is enabled through GPRS module[4, 17] which is connected with Arduino kit and as a result the farmers will get informed about the current intrusion of insects / mammals in the area. ThingSpeak server is installed on the computer connected with Ardiono kit for data analysis purpose. To store the

data on cloud channel "PROJECT_AGRI" is being created on ThingSpeak server ,where separate fields are allocated to each sensor that are field 1 for DTH11sensor (temperature), field 2 forDTH11sensor (humidity) , field 4 for IR sensor , field 5 for Ultrasonic sensor and field 6 for Sound sensor. Sensors devices will send the live data to ThingSpeak server.

5. RESULT

The data captured from the different sensors for the month of February and May 2021 is shown in table 1. Simultaneously all these data are get stored on the ThingSpeak Server live streamed on the cloud for visual analytics.

Table 1: Data collected through various sensors

Date	Time	IR sensor (0,1)	Ultrasonic Sensor (cm) Threshold Value =100	Sound Sensor (Hz) Threshold Value =200	DHT11 Sensor		
					Temperature (^{0}C) Threshold Value =35	Humidity	
						(%) Threshold Value =70	ADC Value (300 - 500)
01 Feb 2021	10:05Pm	0	246	225	20	71	779
	10:07 pm	0	242	71	25	65	797
12 May 2021	02:50 - 3:00 pm	0	12	975	35	73	495
	10:00 - 10:30 pm	0	31	996	35	71	779
	03:45pm	1	16	986	36	61	705
	10:40 - 10:50 pm	1	31	123	35	92	801

Graph shown in figure 2 represents the output for the data (temperature and humidity) received from DHT11 Sensor. Whereas figure 3 reflects the output for the data received from IR, ultra sonic and sound sensors. IR sensor represents the value observed for big animal detection and ultrasonic sensors represents intrusion of small insects in the field.

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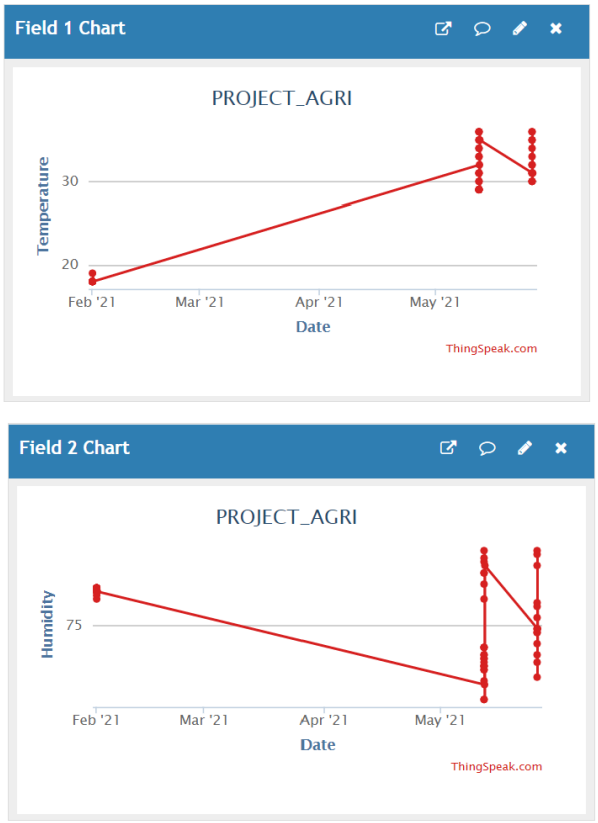

Fig 2: Output from DHT11 Sensor (Temperature and Humidity).

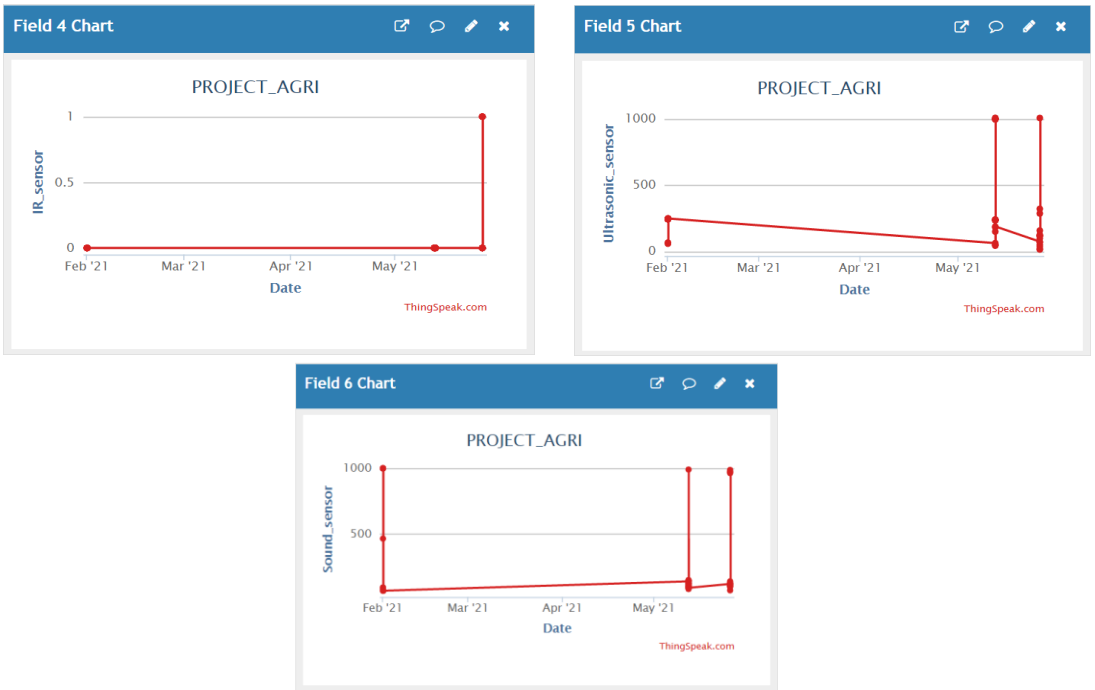

Fig 3: Output from IR, Ultra Sonic and Sound Sensor.

The deployed system (IoT enabled and sensors based) is able to communicate the farmers via SMS in case of tempataure and humidity varaition , insect attack or small/big animals are detected in the field figure 4. By using these infromations farmer can eaisly maintain his farm for better crop productivity.

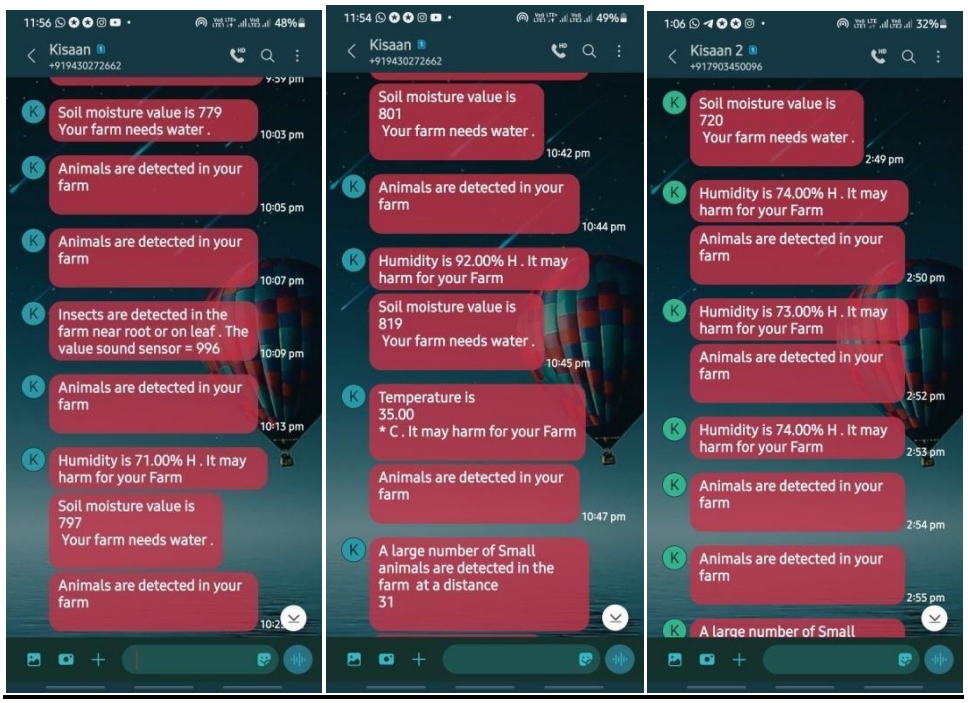

Fig. 4: Messages received by the farmer.

6. CONCLUSION & FUTURE SCOPE

This system can serve as an early warning system for best-in-class risk, as well as a continuous monitoring system that keeps track of the farms. This project is very helpful for farmer. Farmer can know about all types of problem from anywhere without visiting farm land, example if any insect or mammal will in creep in the crops sensor can detect and will send the message to the farmer. Farmer will also come to know about the adequate water requirement for their crops. Farmer can also take precautionary measures in case of temperature variation observed in the field depending on the weather conditions.
The future work in this project is to collect the data for all the seasons and for the variety of crops grown in the field. And further to analyze the data using artificial intelligence particularly machine learning technique to predict the harmful insect intrusion tendency and crop requirement for better yield and better farming.

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