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Technical seminar Report on

"Design and Development of IoT-Based SmartTech-Agri Devices for Smart Agriculture Crop Field"

Submitted in partial fulfillment for the award of the requirement of

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ELECTRONICS & COMMUNICATION ENGINEERING

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CERTIFICATE

This is to certify that the Internship report entitled **"Design and Development of IoT-Based SmartTech-Agri Devices for Smart Agriculture Crop Field"** is bonafide work of **POORVI G S [4MU20EC005]** student of VIII Sem B. E, at **Mysuru Royal Institute of Technology, MANDYA** in partial fulfillment for the requirement of Technical seminar [18ECP83] work of **VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI** during the academic year **2023-2024**. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the report deposited in the departmental library. This report has been approved as it satisfies the academic requirements as prescribed by the university.

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DECLARATION

POORVI G S student of VIII semester Bachelor of Engineering in Electronics and Communication Engineering, MRIT, Mandya, hereby declare that, this dissertation work titled **“Design and Development of IoT-Based SmartTech-Agri Devices for Smart Agriculture Crop Field”** has been carried out independently under the guidance of **MOHAMMED ALI,** Assistant Professor, Department of Electronics and Communication Engineering, MRIT, Mandya in partial fulfillment of the requirement for Technical seminar Report [18ECP83] in Bachelor of Engineering in Electronics and Communication Engineering, affiliated to Visvesvaraya Technology (VTU), Belagavi during the Academic year 2023-2024.

Further declare that, this mini project has not been submitted with this dissertation either in part or full to any other university or institution for award of other degree or any fellow-ship.

Place: Mandya Regards,

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ABSTRACT

Internet of Things (IoT) technology adds new direction to the significant monitoring of soil, plants, and agriculture fields in smart agriculture. In this system, IOT based solutions are employed to enhance the agricultural outcomes and resolve the different problems. Here, an IOT based device is proposed namely “SmartTech-Agri.” This device is designed to supervise the different parameters: soil moisture, air temperature, air humidity, smoke detection, and animal motion detection in the agricultural field. Our proposed device uses a PIR motion sensor to detect movement of intruders, smoke sensor to detect smoke, soil moisture sensor to evaluate moisture percentage, and temperature– humidity sensor to measure environmental temperature in the agriculture field. The proposed design consists of three main major portions: (a) an Arduino-based IoT gadget, (b) a Smartphone application, and (c) a Web server application. The SmartTech-Agri can evaluate different parameters and instantly communicate vital associated information via web-based technologies. The proposed design has been compared with existing recent related works. The accuracy of our device varies from − 2.82 to + 3.85% for humidity and − 2.66 to + 3.14% in case of temperature. This low-cost technology can be utilized for farming production and management in a convenient and effective manner.

Keywords: Smart agriculture, IoT, PIR sensors, Soil moisture sensors, Temperature–humidity sensors, Smoke sensor, Blynk.

CONTENTS

Chapter 1

Introduction

1.1 Introduction

According to a survey, it is predicted that Global population will increase approximately up to 9.73 billion by 2050 and 11.2 billion by 2100. A rise in the demand for agriculture food production increases in direct proportion to population expansion. Food production always hampers due to various environmental issues including climate change and harsh weather conditions. Climate change has a significant negative impact on agriculture due to rising water demands and decreasing agricultural productivity in areas that require the only irrigation. Irrigation technologies based on rain-fed agriculture and groundwater irrigation are required to grow better crops. A diverse irrigation system for managing water, as well as agricultural field monitoring systems, are required in precision agriculture crop fields (e.g., wheat, potato, and onion), where each crop has particular water requirements and agriculture crop field protection. Apart from water management and agricultural field monitoring systems, transferring important information to farmers is essential to supervise and control the ongoing activities without go to the field in real-time.

Researchers in, have considered only the monitoring of soil moisture and environmental conditions but do not handle with field monitoring system in agriculture field from remotely and easily without farmer-field direct contact. Farmers may lack the ability to employ the existing technologies. It plays an important role in changing traditional and new technology from homes to offices and everywhere in between. So, an easy and simple way out is very attractive from the farmer's perspective. The most pressing issues, such as dwindling water supplies and environmental concerns, necessitate a smart agriculture-based solution. A remote sensor network (WSN) is connected to IoT which can be used for a smart water system framework. Thus, employing WSN can provides a way for correspondence, calculation, and data detection from nearby and remote locations. The IoT and sensor network innovation collaborate with the board of water assets for the framework of a water saving system. In this system, the moisture sensor detects the amount of water in soil, a water siphon supplies the essential amount of water to plants, and a Wireless Fidelity (Wi-Fi) block transmits observed data to internet. Then IoT framework has developed, tested, and approved by observing the different parameters of commercial agriculture farming. In this sector, by employing smart farming via IoT can be able to improve operational efficiency, lower costs, reduce waste, and better product quality.

In order to increase the profits, the agriculture sector will need to incorporate new technologies. In this sector, the high labor cost of routine manual monitoring must be reduced. It should be crucial to properly manage water when it is not in use. Recent studies have emphasized the need of smart agriculture in enhancing and growing agricultural output to help close the food supply–demand gap. An efficient and economical smart gadget is very important for precision agriculture system to maximize agricultural farm product, anticipate crop health, and protect crops from animals and fire. To resolve these issues, we have proposed a device namely SmartTechAgri for soil and agriculture field monitoring systems well-being checking framework for improved yield of the harvests, particularly in rural regions where internet is available.

The major contributions of our research work are as listed below:

i. Design a real-time smart device for agriculture crop fields using IoT to measure and monitor the health condition of soil as well as condition of environment.
ii. Proposed device is also responsible for safety and protection of agricultural field especially in firing condition, and attacking of birds and animals.

The rest of the paper is organized as follows. The Sect. 2 discusses the related existing works. Architecture of proposed design is given in Sect. 3. The flowchart and working procedure are presented in Sect. 4. The detail design of proposed work is presented in Sect 5. Implementation of our proposed designs is described in Sect. 6.

Details observation of our proposed designs is explained in Sect. 7. In Sect. 8, the paper is concluded

1.2 Related Works

In this section, different existing related works are discussed briefly. The wireless sensor network (WSNs) with the AgriSens architecture consists of various parts like water level sensor, sensor node, remote server, and IoT gateway [6, 11, 12]. Adopting a WSN is anticipated to address both system-level concerns and end user needs for effective agricultural monitoring. It is difficult to compare all of these topologies because several WSN topologies have been built, and each topology has its own scenario. A conceptual architecture based on WSN namely Farm Fox architecture is described in [7], which is cost-effectiveness, user friendly, versatile, energy competence, reliability, and hardiness. In [14], a low-cost agro-climatic monitoring system based on the IoTs is made up of a number of stations placed both inside and outside the greenhouse and connected to an IoT platform via a WSN. Each station is equipped with a variety of sensors to detect many variables including humidity, temperature, soil moisture, wind direction, wind speed, precipitation, pH, radiation, etc.

Precision farming with IoT technologies like AgriTalk does for the cultivation of turmeric which improved the quality dramatically [15]. A low-cost, highly accessible IoT platform for agriculture is introduced namely Farm Beats [16] which utilizes TV White Spaces (TVWS), long-range technique that supports high bandwidth sensors. This Farm Beats employs an intelligent Gateway and a weather aware base station to make sure that services are accessible both online and offline. There are also new path-planning algorithms that help to extend the battery life of drones [16].

Small amounts of water and electricity can be used to cultivate healthy plants. The authors in [17] primarily focus on cultivating tomato plants, which were successfully cultivated using an IoT-based automated approach. In this approach, a Node MCU is used to drive the DC motor and IoT technology is utilized to evaluate the different parameters such as soil moisture level, humidity level, temperature, and rain status. These parameters are all transmitted through Wi-Fi to the smart phone [18].

A system is designed that could automatically adjust the humidity and temperature of a confined environment and VLSI systems can be used to achieve inexpensive automation [19]. The design in

[20] is an agricultural embedded system based on CMOS technology and it is used to implement the FPGA board [20]. With data monitoring utilizing LoRa and IoT Technology for smart farming, this effort is reviewed in real-time, with temperature, humidity, and soil moisture regularly communicated to the cloud with better data quality (QoD) [21].

In order to prevent animal invasions into crop fields, the authors describe the creation of a WSN application for crop safety. The nodes in the agricultural field have RF modules, LED flashers, PIR sensors, and sound generators. An intrusion detection system is installed to allow for early identification of the animal in the field [22].

In [23], an automatic irrigation system is used to manage and track irrigation. For precise field monitoring and control, two different types of sensors are employed. The PIC microcontroller serves as the project's brains for automatic irrigation and the PIC's internal ports are attached to the moisture and touch sensors [23].

The authors of [24] suggest an IoT-based smart stick that will enable ranchers to have real-time information about soil moisture and climate temperature for a very low-cost, allowing for live monitoring. The study in [25] shows the detail design and construction of a system that tracks humidity, temperature, and soil moisture at the agriculture field level. An IoT scheme in horticulture is made up of electronic devices that supervise the condition of air, water, and soil [26].

Chapter 2

Architecture of Proposed "SmartTech-Agri"

The architecture of SmartTech-Agri is briefly illustrated in Fig. 1. In our proposed device, we have employed the traditional conceptual architecture of WSN which is based on the architecture of IoT. The proposed SmartTech_Agri is combined with three layers which are discussed in the following

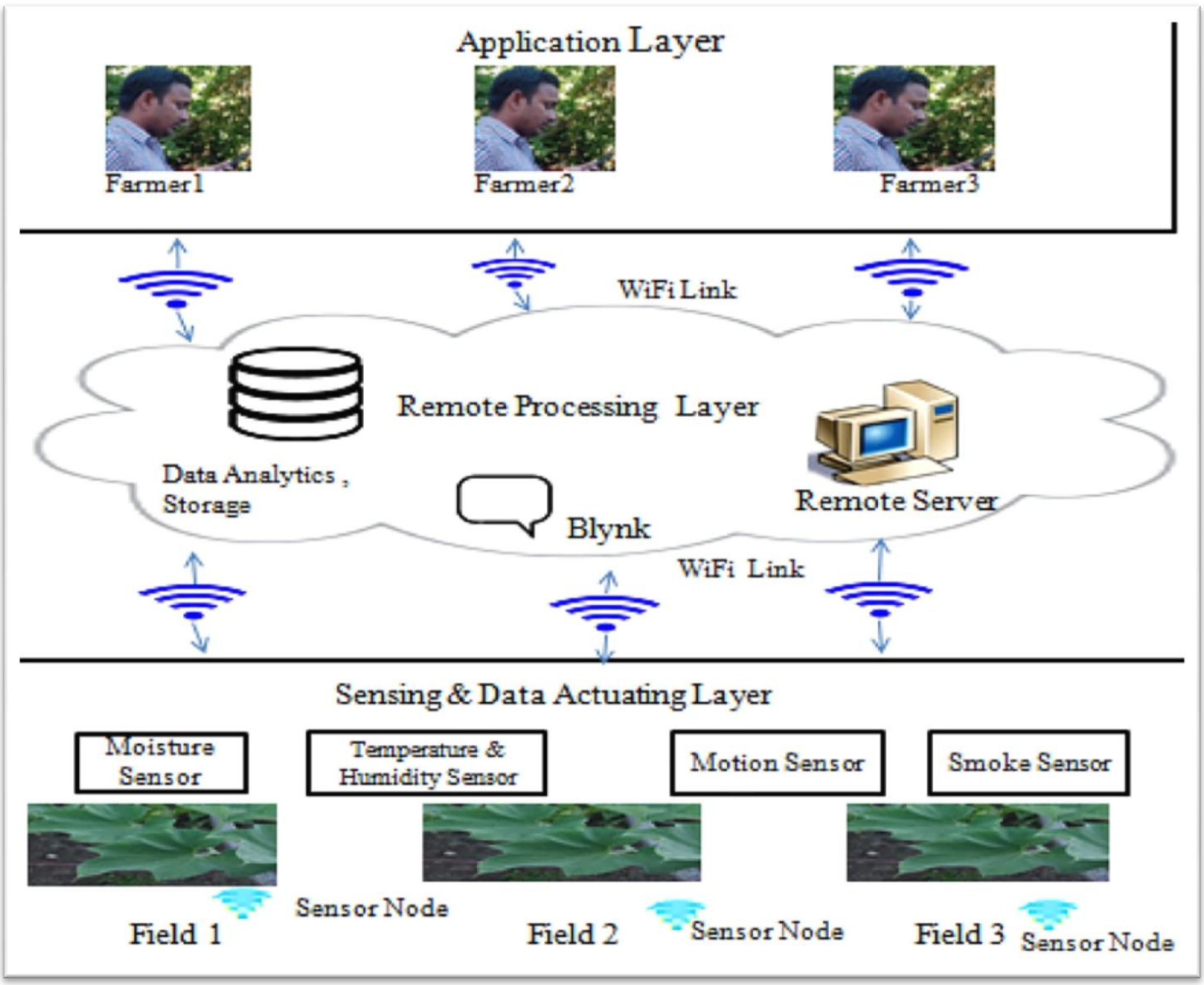

Fig 1 Architecture of Proposed "SmartTech-Agri"

(a) *Sensing and Data Actuating Layer* Wi-Fi technology is used by sensor nodes in the field to collect data about the field's properties and transmit it to IoT gateway nodes. The data are then sent as packets by the gateway nodes to the distant server. In order to facilitate the integration and interconnection of virtual and physical entities, Wi-Fi produces the fundamental IoT-based communication architecture.

(b) *Remote Processing Layer* It is the middle layer between the bottom layer and upper layer. Smart technology organization processes requests as well as data from the top and bottom layer. The advantage of being able to oversee field operations from a distance is made possible by the remote processing layer.

(c) *Application Layer* The farmers may easily utilize the analytics to visualize the data that has been collected on their smart phones and personnel computers (PCs) with the aid of an internet and Wi-Fi connection. The farmers can locate a specific node's position Additionally, farmers can view their field data at any time via the Web server utilizing the Internet. Through Wi-Fi and the internet, farmers can also manage field operations in accordance with requirements. In the next section, flowchart and working procedure are discussed.

2.1 Proposed flowchart of SmartTech-Agri Devices using UNO_ R3_ATMEGA328P

The flowcharts of SmartTech-Agri for two different microcontroller units are given in Figs. 2 and 3. Figure 2 represents the flowchart of proposed SmartTech-Agri devices. using UNO_R3_ATMEGA328P. The proposed design works as follows.

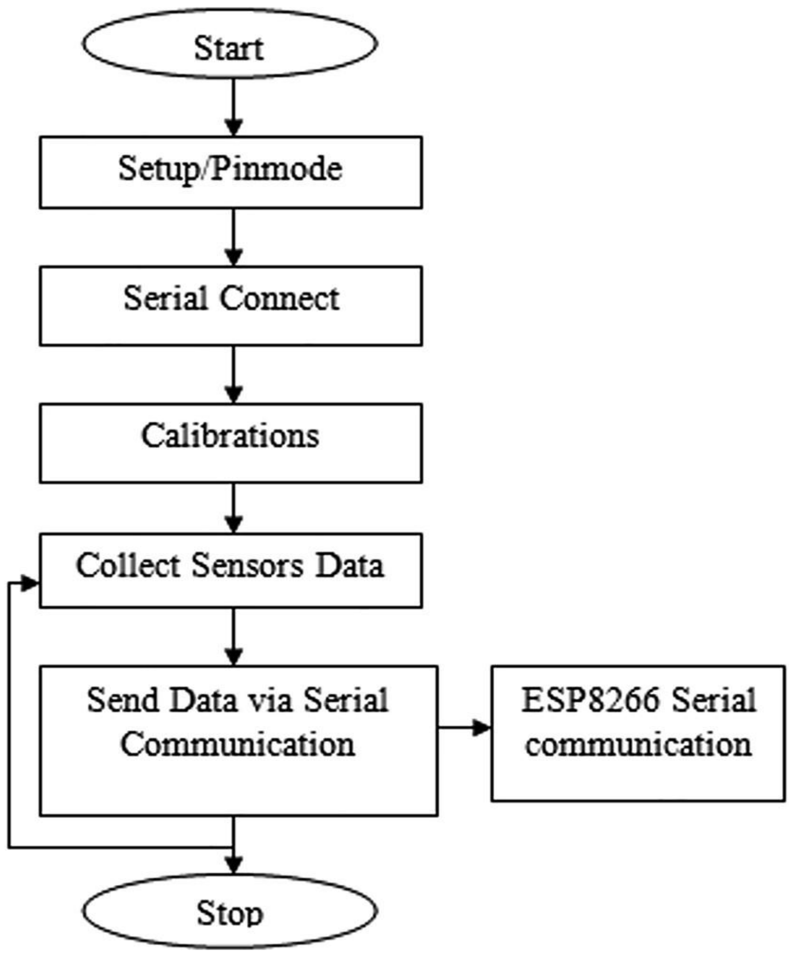

Fig. 2 Flowchart of proposed SmartTech-Agri Devices using UNO_ R3_ATMEGA328P

2.2 Architecture Proposed flowchart of SmartTech-Agri Devices using UNO_ R3_Wi-Fi_ATMEGA328P _ESP8266

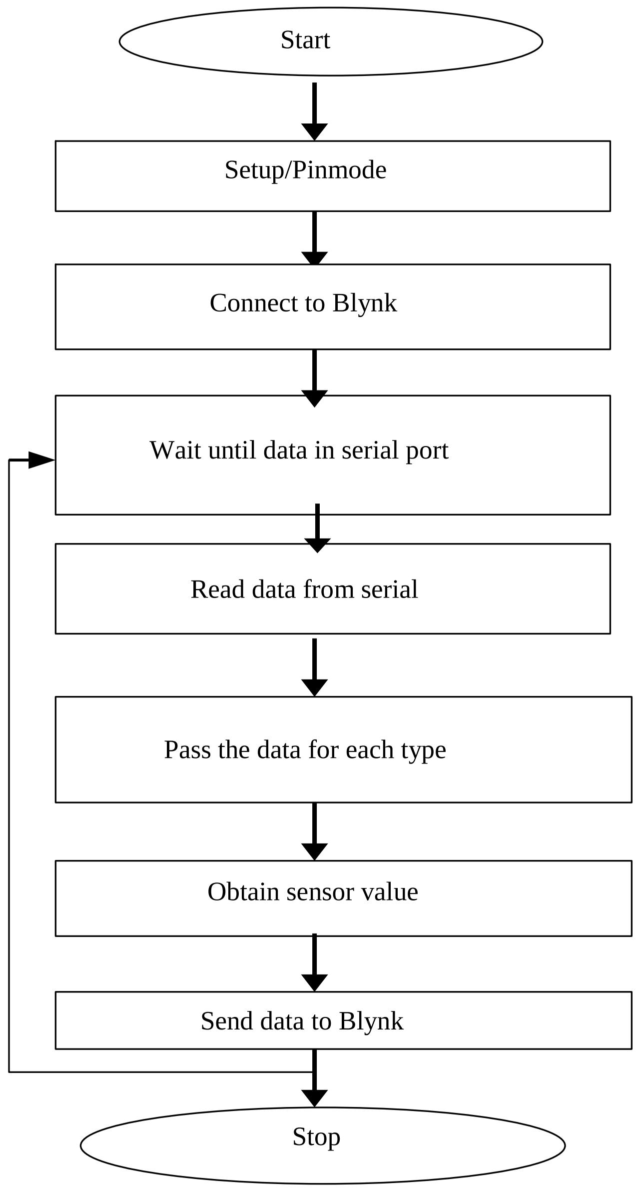

Fig. 3 Flowchart of proposed SmartTech-Agri Devices using UNO_ R3_Wi-Fi_ATMEGA328P_ESP8266

The steps of working procedure of Fig. 2 are represented as follows:

1. First set up pin mode.
2. Connect with serial port to ESP8266 with a baud rate of 115,200 bps.
3. Wait for smoke and motion signal (To calibrate the result keep smoke sensor in clear air and PIR sensor away from motion. LED will blink when it is calibrated.)
4. Collect sensor data one by one and send to ESP8266 via serial port with delay of 3 s.
5. Repeat step 4.

Figure 3 represents the flowchart of proposed SmartTech-Agri devices using UNO_R3_Wi-Fi_ ATMEGA328P_ESP8266 and their working steps are shown in the following.

1. Set up pin modes buzzer will beep 2 times after this.
2. ESP8266 to connect with Blynk software, make sure Wi-Fi is ON, buzzer will beep 2 times.)
3. Wait for data available in serial port.
4. Read the different data from serial port and pass the data for each type through Blynk.
5. Obtain sensor value from data and send to Blynk.
6. Repeat step 3.

Chapter 3

Design of SmartTech-Agri

3.1 Design of SmartTech-Agri device

The details of proposed SmartTech-Agri have been presented here. Details of all sensors are also presented in this section. A. Block Diagram of SmartTech-Agri Device:

Cost-effectiveness, energy economy, reliability, and resilience are the main concepts that drove us to build these nodes.

3.1.1 Integrated Design of the Sensors Four sensors that have been recalibrated and utilized to measure moisture, temperature, motion of birds or other animals, and fire detection. The PIR sensor detects intruders near the field, soil moisture sensors measure the percentage of moisture content of the soil and smoke sensor senses.

i. *Moisture Sensor (REES52)* The resistance of the fork shaped moisture sensor probe varies with soil moisture content and operates as a variable resistor (similar to a potentiometer). Soil conductivity and resistivity improve as soil moisture content increases. We can determine the soil moisture content by measuring the output voltage generated by the sensor in accordance with the resistance. To get our threshold value, we will first take an analogue reading from absolutely moist soil. If the analog reading exceeds this value, we will notify the user to water the soil.

ii. *Smoke Sensor (MQ-2)* The smoke sensor can be used to detect flammable gas leakage and smoke. All the measuring parameters of this sensor can be measured from the datasheet of MQ-2 [27]. It is shown that the clean air has Rs/R_0 value of 9.8. We can determine the R_0 value of fresh air using this ratio. By running the sensor in fresh air and applying the analogue voltage output of the sensor according to Eq. (1), we can determine the *Rs air* value of fresh air by analyzing the circuit of the MQ-2 sensor.

Rs air = ((5.0 − Analog Voltage) ⁄ Analog Voltage)

We can calculate the value of Rs air of fresh air from the Rs/R_0 ratio. Now the *Rs air* and Rs/R_0 will change in the presence of smoke, and since *Ro* is fixed, we can compare this information with the data sheet to estimate the smoke concentration.

iii. *Temperature and Humidity Sensor (DTH11)* This is a low-cost digital temperature–humidity sensor which computes the temperature and humidity in soil and environment. This sensor consists of 3-pin. Its data sensor output pin is connected with microcontroller digital pin.

iv. *Motion Sensor (PIR)* The motion sensor **(**PIR) detects the movement of a human or animal within a range of around 10 m across the sensor placed in the agriculture field. This PIR sensor is capable of detecting different infrared radiation levels. The majority of PIR sensors feature a 3-pin connector on the bottom or side. One pin will be utilized for ground, another for signal, and the last for power. Power levels of up to 5 V are normal. The PIR sensor's output remains low until motion is detected. It takes some time for the PIR sensor to warm up and begin functioning properly.

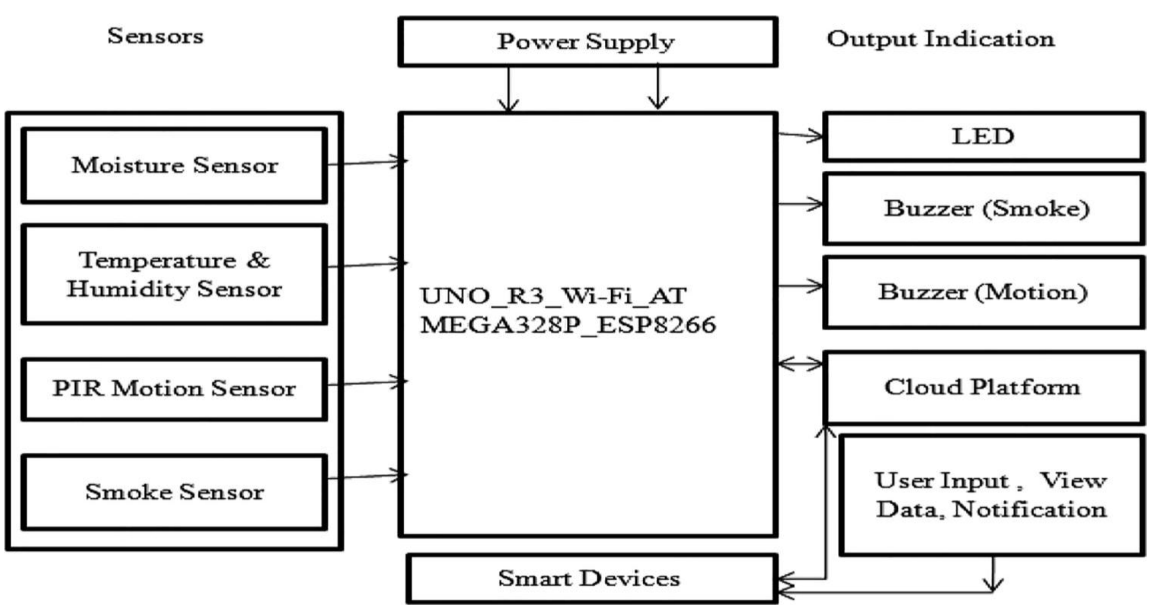

Fig. 4 Block diagram of SmartTech-Agri

3.1.2 Integrated Design of IoT Gateway It serves as a communication bridge by establishing connections between the sensors and other devices like Wi-Fi, Bluetooth, etc. using internet. In SmartTech-Agri, an IoT gateway is employed to pass data from field to the processing unit. To achieve the stated goal, Wi-Fi and TCP two widely utilize protocols, are used. We have created a webpage for managing and keeping track of the sensors. Additionally, it aids in the sensor data retrieval.

3.1.3 Integrated Design of Remote server We have created a Web server as part of our design. The file that makes up a website are kept on the web server along with the web server software. The servers are kept in a cloud-based environment. The SmartTech-Agri system is a "unique system for precision agriculture" since it uses this server to monitor the soil health monitor, intruders close to the field, and a smoke sensor to identify the smoke emitted from the fire.

3.1.4 Integrated Design of Sensor Nodes In order to produce SmartTech-Agri, sensor nodes are organized in a waterproof design. The android application displays the different parameters like temperature, humidity, soil moisture, smoke, and motion which can be programmed into a microcontroller.

3.2 Circuit Diagram of SmartTech-Agri Device:

We have used UNO_R3_Wi-Fi_ATMEGA328P_ ESP8266. It is used to obtain the sensor nodes active sleep mode. The UNO_R3_Wi-Fi_ATMEGA328P_ESP8266 microcontroller is low-cost compared to other commercial alternatives. The device’s reliability qualification findings show that the expected data retention failure rate is substantially less than 1PPM during a 20-year period in hostile atmospheric conditions [12]. Figure 5 shows the circuit diagram of our proposed SmartTech-Agri device. The connections between the various node components and the processor are shown in below figure.

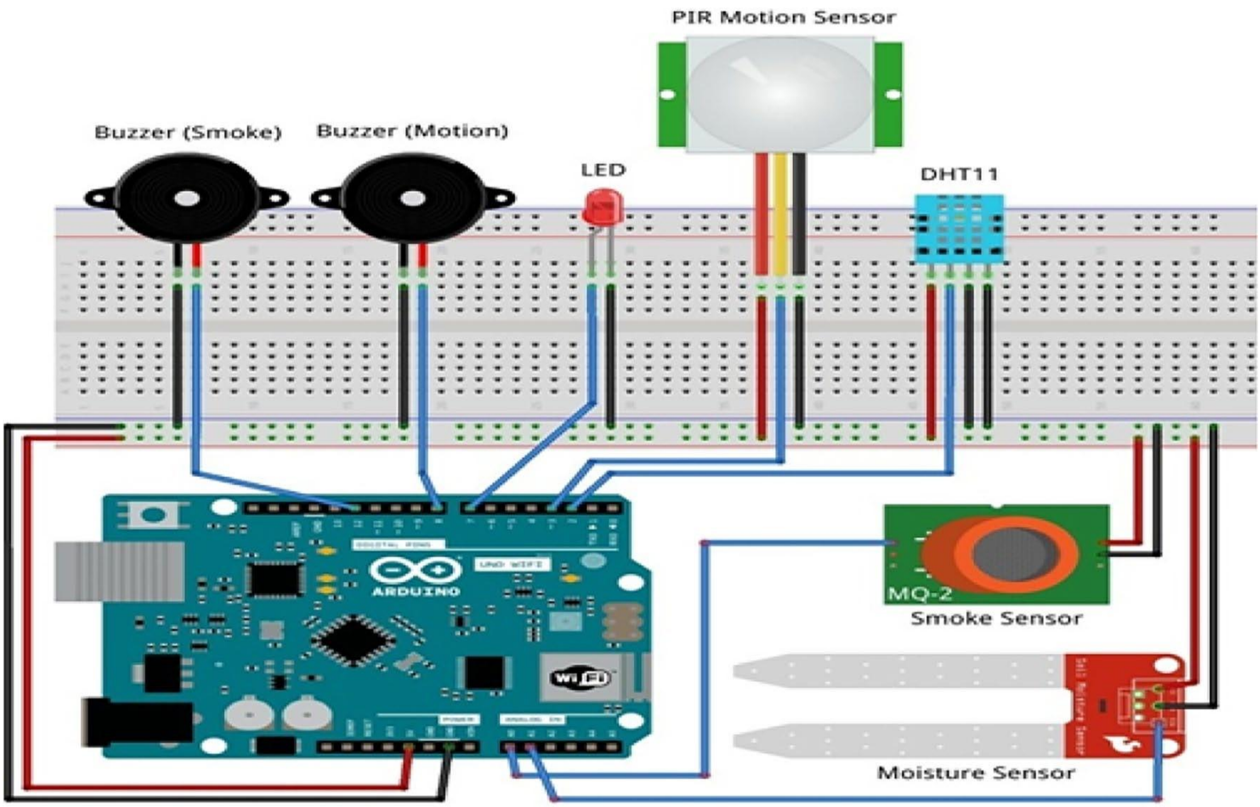

Fig. 5 Circuit diagram of proposed SmartTech-Agri device

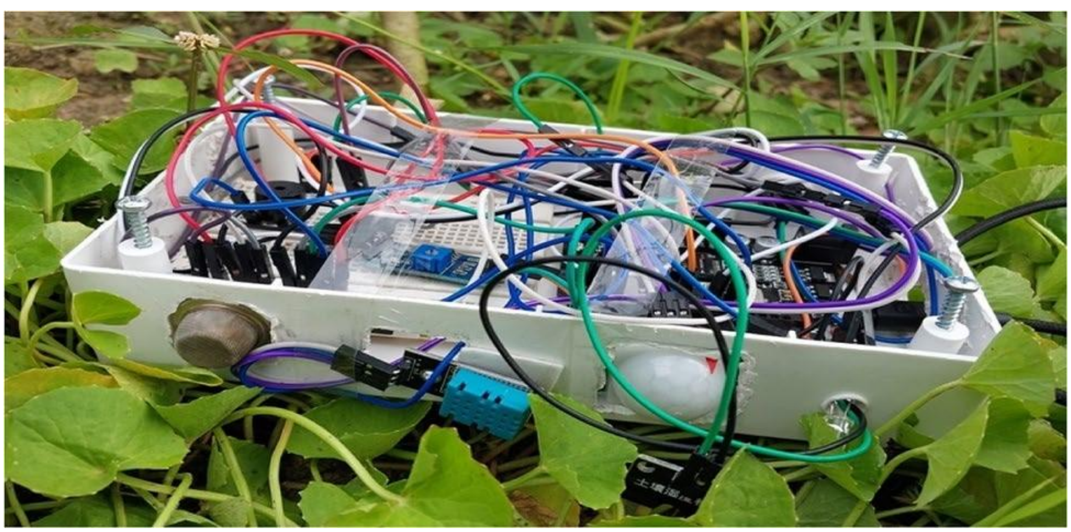

Fig. 6 Proto-type model of SmartTech-Agri device

3.3 Implementation of SmartTech-Agri

After successful design of our proposed SmartTech-Agri device, we have to implement the prototype of our model. Experimental set up is shown in Fig. 6. It shows the SmartTech-Agri prototype of our proposed device which will monitor the different parameters of agricultural crop field. The humidity sensor, temperature sensor, soil moisture sensor, smoke sensor, motion detection sensor, buzzer, LED, relay, and motor are all connected to the microcontroller UNO_R3_Wi-Fi_ATMEGA328P_ESP8266. These sensors detect numerous soil parameters, and a motor is then used to provide the soil with water. The power supply for this microcontroller is 5 V DC is required to operate it. Moisture sensor is measured the soil moisture content in agricultural soil; the temperature and humidity sensors are measured the temperature and humidity in environmental condition in agriculture field; Smoke detector is detected the smoke of fires; and the PIR sensor is detected animals crossing fields by detecting their movement. Wild animals become agitated when the buzzer is used, and they vacate the place. The UNO_R3_Wi-Fi_ATMEGA328P_ESP8266 microcontroller contains a Wi-Fi module that enables access to upload data to the cloud. The cloud-based web server for IoT applications (Blynk), is a basically open source. It can be operated by supplying a username and a password; we have developed our own channel for IoT-based agricultural monitoring. We will submit data via the Blynk API so that we can observe the soil moisture, temperature, humidity, smoke, and animal detection through the sensors on the web with visualization on a Blynk platform.

This device displays the various readings based on various parameters. The Status LED has started to glow; it can set the threshold by positioning the gas sensor close to the smoke or gas you want to detect. After that, it turns around till the LED turns off. This sensor detects upto ranges approximately 5 m. Whereas, PIR sensors detect the distance ranges from around 25 cm to 20 m. If any animal or bird close to within the detection range then the LED will ON otherwise the LED will OFF.

Table 1 represents the performance comparison of SmartTech-Agri device with existing work. Cost of the proposed device is approximately four thousand only. So our device is cheaper compare to all existing designs [6, 7].

Chapter 4

Result

4.1 Result Analysis

Here, we have discussed the details of results obtained from our experiment setup. The snapshots are directly taken from our implemented project.

Figure 7 demonstrates how the hardware is examined for moisture, humidity, soil temperature, motion, and smoke. It also mentioned the actual values.

Visualization of sensed data displayed on Android application is shown in Fig. 8 for our experiment set up. We have collected all the data at Balichak, West Bengal, Paschim Medinipur (latitude:22.360145 and longitude: 87.55689), during August–September, 2022. All the observations are shown in Table 2 for duration of 15 days.

The reading differences between the farm meter (thermo-hygrometer) and used sensors for the nearby weather node are observed in Table 3. The digital thermohydrometer and DHT11 have variation between − 2.66 and 3.14% for temperature. It is observed that there is not much of an average temperature difference between the thermo-hygrometer and DHT11 sensor. The reason for the little variation is that DHT11 measures temperature in positive integers, which have a range of 0–50 °C. The DHT11 and digital thermo-hygrometer results have an average humidity variation between − 2.82 and 3.85%. Different humidity measurement ranges are the cause of the reading discrepancy between the sensor and digital thermo-hygrometer readings. So accuracy of our proposed device is nearly within an acceptable maximum tolerance level of ± 4%.

4.2 Comparisons of SmartTech-Agri with other existing systems

SI. No	Features		AgriSens	FarmFox	SmartTech-Agri
1	Microcontroller		ATMEGA324PA	Arduino NANO	UNO_R3_Wi-Fi_ ATMEGA328P_ ESP8266
2	Number of sensor nodes		4	3	4
3	Programmable		Yes	Yes	Yes
4	Communication protocol		ZIGBEE & GPRS	WI-FI & TCP	WI-FI & TCP
5	Remote monitoring		Web server	Web server	Web server, Android application
6	Name of output devices	Buzzer	No	No	Yes
		LED	Yes	Yes	Yes
7	Device cost		Low	Low	Lower

Table 1 Comparisons of SmartTech-Agri with other existing systems

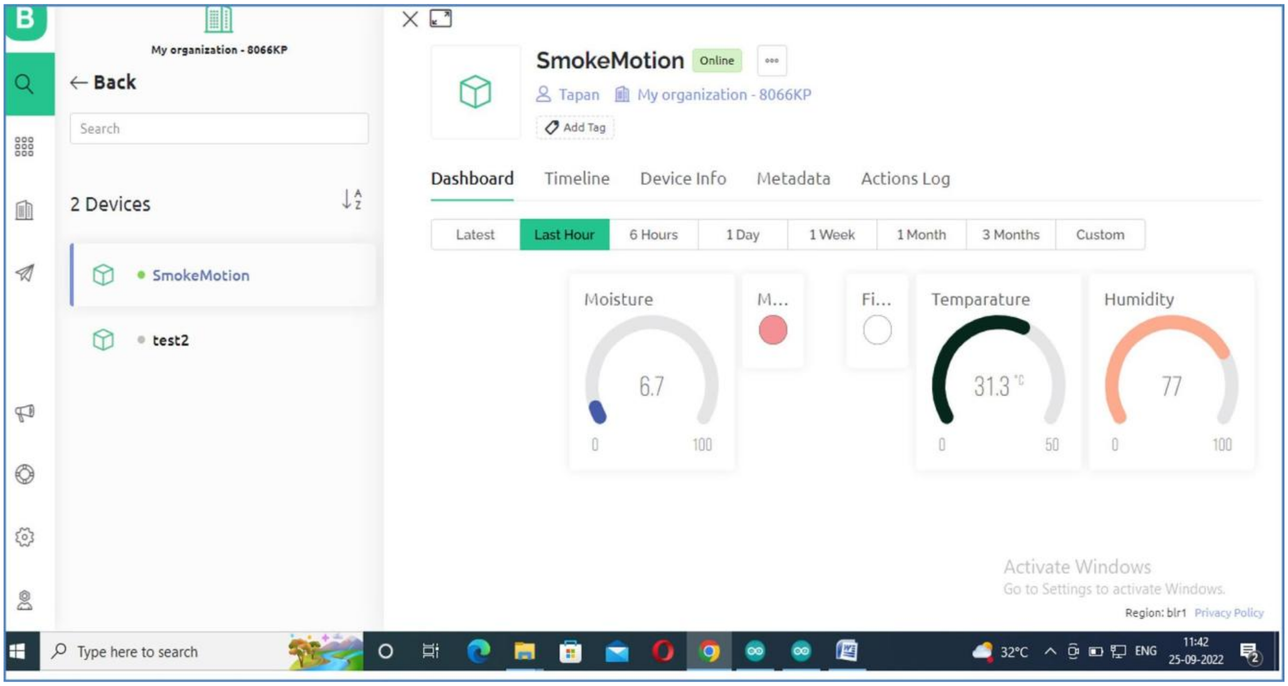

Fig. 7 Visualization of sensed data displayed on user Web application

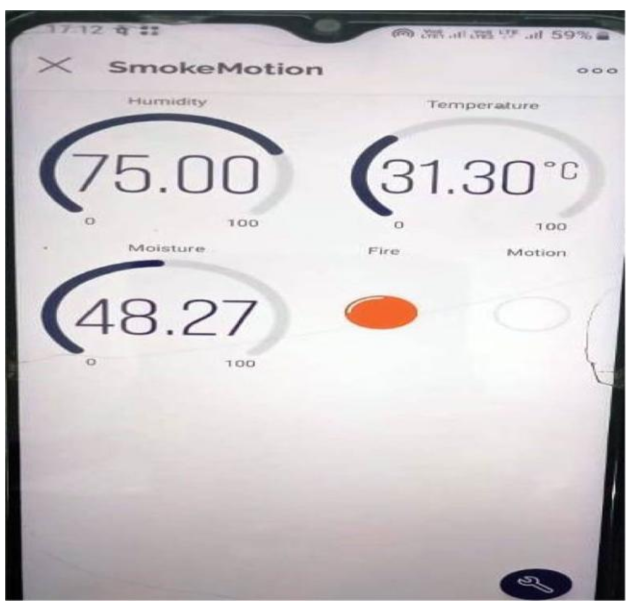

Fig. 8 Visualization of sensed data displayed on Smartphone

4.3 Data accuracy analysis

SI. No	Time (Day)	Temperature DTH11(℃)	Moisture (%)	Humidity (%)	Fire alarm	Motion alarum
1	Day 1	31.3	69.89	75	No	No
2	Day 2	30.8	68.59	74	No	Yes
3	Day 3	30.9	66.96	75	No	No
4	Day 4	31.3	48.27	75	Yes	No
5	Day 5	31.3	36.27	76	No	No
6	Day 6	30.7	05.87	75	No	Yes
7	Day 7	31.3	06.70	77	No	No
8	Day 8	30.8	06.36	75	No	No
9	Day 9	30.8	36.17	74	No	No
10	Day 10	31.8	46.27	73	Yes	No
11	Day 11	31.4	56.28	73	No	No
12	Day 12	30.8	67.28	73	No	Yes
13	Day 13	31.3	66.80	74	Yes	No
14	Day 14	31.5	68.89	74	Yes	No
15	Day 15	31.6	66.28	75	No	No

Table 3 Data accuracy analysis

4.4 Data collected from

SI. No	Time (Day)	Digital thermohydrometer, temp. (°C)	DTH11 temperature (°C)	Variation of temp. (%)	Digital thermohydrometer, humidity (%)	DTH11 humidity (%)	Variation of humidity
1	Day 1	31.0	31.3	-0.97	77	75	2.60
2	Day 2	30.2	30.8	-1.99	75	74	1.33
3	Day 3	30.1	30.9	-2.66	78	75	3.85
4	Day 4	31.6	31.3	0.95	74	75	-1.35
5	Day 5	31.8	31.3	1.57	79	76	3.80
6	Day 6	30.1	30.7	-1.99	78	75	3.85
7	Day 7	31.9	31.3	1.88	75	77	-2.67
8	Day 8	31.0	30.8	0.65	77	75	2.60
9	Day 9	31.8	30.8	3.14	75	74	1.33
10	Day10	31.3	31.8	-1.60	71	73	-2.82
11	Day11	31.9	31.4	1.57	75	73	2.67
12	Day12	31.1	30.8	0.96	77	75	2.59
13	Day13	32.0	31.3	2.19	73	74	-1.37
14	Day14	31.9	31.5	1.25	75	74	1.33
15	Day15	31.2	31.6	-1.28	76	75	1.32

Table 2 Data collected from

Chapter 5

Conclusion

The IoT has been employed in agriculture to increase crop yields, enhance quality, and lower expenses. Hence, we have proposed an IoT-based SmartTech-Agri device to monitor the soil condition and field monitoring of precision agriculture. The proposed device is designed and employed in agricultural field. We have observed the real-time data from different sensors placed in agriculture field. Cost of SmartTech-Agri device is very low. Accuracy of the proposed device is up to the satisfaction level. If the farmers successfully employ this agricultural IoT-based solution, they will produce enough crops for the upcoming population's rapid growth. The cloud sense data will likely be utilized in our future research to build the machine learning models for intelligently automated in precision agriculture.

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Declarations

Conflict of interest the authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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