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Smart farm and monitoring system for measuring the Environmental condition using wireless sensor network - IOT Technology in farming

Tharindu Madushan Bandara
Wanninayaka Mudiyanselage
School of Computing and Mathematics
Charles sturt University Study Centre
Melbourne , Australia
bandaratharindu07@gmail.com

Mansoor RAZA
School of Computing and Mathematics
Charles sturt University Study Centre
Melbourne, Australia
maraza@studygroup.com

Abstract— **Internet of things (IoT) gives a new proportion of smart farming and agriculture territory. Because with the development of the current world, the internet of things field has peaked with modern technology and modern techniques. In the modern world, IoT is used in every domain like smart city, smart university, smart car park system, etc. This paper is about the implementation of the smart farm. IoT concept helps in cost-efficient farming activities like crop and other resource management. With a wireless sensor network, it is easy to connect with every sensor node placed in the farming environment. Also, with the wireless sensor network, it can connect with long-distance ranges. With the help of a sensor network, it can collect the data from the farming environment and analyze it according to the pre-defined values. The proposed system used IoT sensors to collect the data are soil moisture sensors, temperature sensors, water volume sensors, etc. According to the existing system analysis, the proposed solution contains a smart farm environment and a real-time monitoring system with the wireless sensor network for node connectivity. The proposed system provides a more reliable and flexible smart concept for the farmers, and it is a simple architecture that contains the IoT sensors that collect the data from the farm field and transfer those data through wireless sensor network to the central server and according to the input data, the primary server assigning the task to the particular devices.**

***Keywords*: Internet of things (IOT), smart farming, wireless sensor network, sensor nodes, smart devices.**

I. INTRODUCTION

The Internet of things (IoT) is connected to human life more efficiently in the modern world. Farming and agriculture are the better sources of providing foods, grains, and other raw materials to human life. In the past, most farmers are doing their farming activities with their experience gain by the previous generation. However, the experience and skills cannot be gathering from the previous generation in the now and future. The reason for this situation is, anyone is not like to work with the ancient methods. The new generation is looking for new technology techniques and smart devices to do their day-to-day activities. Technology has considerable power to increase productivity and reduce the extra human resources from the farming environment. With the help of Internet of things (IoT), it has opened more solutions to smart farming. [9] When talking about the smart farming concept with the Internet of things, collecting information from the sensors placed in the farming environment is the main challenge. There will also be another challenge: how it can connect each sensor node to another sensor node.

There is a mechanism which is implemented already in this smart farming concept. It is the wireless sensor network that connects every sensor node. Wireless sensor network (WSN) is a modern technology used to connect sensors, sensing nodes quickly to the main system board. For the farming environment, it needs to connect the sensor nodes with long distance. With this process, it is hard to connect with the wired connection. So wireless sensor network is using in this process. It will also provide digital transmission, long-distance transmission, low power consumption, real-time monitoring, etc. With the use of different kinds of IoT devices, WSN usage can be varied in WSN. However, the smart farming environment helps gather real-time information/data from the farming environment through the sensors.

Most of the time, soil moisture, temperature, humidity, water level, etc. will measure with the sensors, and collected data/information needs to transfer through the wireless sensor network (WSN). The smart farming concept needs to develop a real time monitoring system to increase the farming environment's productivity. With the help of a real-time monitoring system, it can monitor the real-time soil moisture, temperature, water level humidity, etc. in the farming

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environment. Also, with smart devices' help, it can develop the smart device application to monitor and control the water level and some other environmental facts to ensure the proper maintenance of the farming environment. With the help of real-time monitoring, it can monitor the real-time water level, soil moisture, temperature, etc. in the farming area, and then it can control the water level that suitable to a particular plantation without exceeding the limit of the sources. Previously, the plantation process's environmental conditions are not addressed well for the farmers. The farmers only looking from physically and do their farming without any other related or supportive information. Nevertheless, with the help of smart farming technology with the Internet of things (IoT), it will become a more reliable and flexible process for farmers. Because of the smart farming concept, it introduced monitoring and controlling the environmental condition. [7] The next sections in this article will discuss the real time monitoring system, sensor node data collecting mechanism, data transferring mechanism through the wireless sensor network (WSN), and smart device application for controlling and monitoring. We will also discuss future works and discuss how those changes can be used with the existing system.

II. Literature Review

In this literature review, the author sought out and studied various research papers on smart farming aspects with the wireless sensor network in the internet of things (IoT).
The modern world of the internet has used some more techniques and technology to develop a more reliable and efficient system for the smart farming environment. [4] has implemented a system to monitor the environmental condition using sensors with Wi-Fi technology to connect the sensors and transfer the data to the central database. This system authors have collected sensing data from soil moisture sensors, water volume sensors, soil ph sensors, air temperature sensors, and motion detection sensors. They have also implemented two algorithms for the soil moisture sensor and air temperature sensor to get real-time monitoring more efficient. With these authors, they have introduced a poly house concept that helps protect the crop from harmful sunrays, heavy rainfall, storms, and other factors that can harm the crop. Also, [3] these authors have implemented a system similar to the previous one, with some more development with a smart dashboard, smartphone controlling system, and they have included the power consumption monitoring system for their research work. Also, in this research work, they have to use actuators. They use this actuator for pest sprays in turmeric cultivation. They have also used sensors to measure environmental conditions such as temperature, water level, and soil moisture. They have used the Arduino microcontroller board to connect all IoT devices and use the cloud platform to transfer and store the information/data collected from the sensors.

According to [5], they have developed an aeroponic system that uses artificial intelligent sensor techniques to monitor the plantation process and provide the plantation process's proper environmental conditions. In this system, it will divide the plant into two parts roots and leaves. This system mainly focuses on the plant and leaves in the plant and will monitor the water level, air pressure, and some other environmental conditions using intelligent sensor techniques. In this system, they have used a wireless sensor network to transfer the data to the central server and collect information to monitor the real-time feeding. With this system, they have monitored the environmental conditions such as humidity, temperature, ph value, etc. also with this system, they have use IOT devices to collect the information from the plantation, and it will directly send those data to the IoT gateway and those data stores in the server platform. Also, it provides space to access the client through smart devices and web applications. They have to use a Wi-Fi data logger to connect with the internet.
Most of the time, there will be some problems in this smart farming environment that can occur at certain times. Like network issues, sensor data issues, sensor failures, hardware failures, etc. According to the [8] researchers, they have addressed some key issues which can occur in smart farming with the internet of things (IoT). They have analyzed the existing farming culture with the internet of things (IoT), analyze the current standards and protocols applicable in IoT, analyze the specific trends and opportunities to develop IoT in the farming environment, etc.

After analyzing all these areas, they have focused on the internet of thing (IoT) networks used in the smart farming environment, and they have analyzed the networking issues, networking techniques, and new networking trends in smart farming. According to this paper, they have analyzed the network schema which is called LoRaWAN schema, which collect the data from the sensor nodes and transfer those data through the LoRaWAN mode (gateway) to the LoRaWAN cloud service and from LoRaWAN cloud service, it provides space to access those data and monitor those data for the clients using their laptops and smartphones. In this research paper, researchers are mostly analyzing the schemas in the farming environment with IoT and provide depth introduction and provide more efficient addressing about the network schema.

Similar to the above analysis [10], these researchers have evaluated the platform for the crop performance analysis and recommendation called SmartFarmNet platform.in this platform, researchers have implemented a mechanism to sensor discovery techniques search the sensor metadata. Also, with the SmartFarmNet, they have implemented new trends and techniques towards smart farming. They have provided space to the farmers to bring their own IoT devices up to 30 IoT devices to the farming environment, providing a more reliable and efficient platform for the users. Real-time monitoring is the most critical function in a smart farming environment. In this research paper, they have implemented a real-time data analyzing mechanism for the users. They have collected information from the existing systems and also use their experience and lesson learned from the past to analyze the research works and implement the SmartFarmNet platform to the smart farming environment. Also, they have provided space for the future researchers to collect data, analyzes information to their research works by providing virtual lab platform which store SmartFarmNet platform data in the virtual labs. They have implemented their gateway called SmartFarmNet gateway to filter, collect, and collate data streams from virtually IoT devices.

In the present world, most researchers, those who do their research based on the smart concept in the IoT platform, use wireless sensor network (WSN) for their systems data collection and IoT device connecting processes. [1] this research work has to use a wireless sensor network to implement their system. According to the research paper, they have used a moisture sensor to get the environmental condition from the farming environment, and those collected data are transferred through the wireless sensor network (WSN) to the central database. They have used WSN minimum as possible to optimize the performance of the system. The data collecting process is a little bit different from other researches. They have collected the moisture level and categorized those data as normal moisture, high moisture, and low moisture. The sensors will indicate the high reading as the high moisture, regular reading as normal moisture, and low reading as the low moisture. With this research, they have implemented a system to monitor IoT devices' connectivity, which is connected to the mainboard. The client interface for the client has been implemented in this research project to increase the smart farming concepts' productivity with the IoT in the modern world.

[2] According to this research work, they have designed IoT-based smart farming to control high voltage electrical devices like a pump, flap of playhouses, etc. depending on the environmental parameters like soil moisture and temperature. According to this research, they are mainly focused on farming done in the playhouse with the proper environmental conditions, and the researchers are going to implement a system to control those conditions using the IoT device and Wi-Fi technology for data transferring and data storing. In this research, they have divided their system into four model layers. such that sensor layer which collects the sensor readings from the farming field, middleware layer to automate the farming process and control the actuators and in here they are using microcontrollers, communication layer is introduced to microcontrollers to communicate with the gateway through the Wi-Fi technology, and the final layer for the cloud and application layer to recording and store the farming field data. Also, in this research, they have developed a prototype model for their proposed system.

[6] proposed a system called Agri-IoT, a semantic framework for IoT based smart farming application. This application provides space for the large-scale data analytics and event detection mechanism for the farmers using the Agri-IoT application. The researchers are implementing a layered architecture for the proposed system, including lower-level devices and communication planes, intermediate layers for the data and data analytics, and a higher layer for the application and end-user planes. In each layer, various software components provide specific operations related to data analytics. Also, in this system, they have included a data wrapper. It offers a generic way to describe the sensors' characteristics, device manager, which automatically manages and controls the IoT devices and discovery model to discover the IoT devices and services in real-time. Data aggregation to analyze a large amount of data, data federation for answer the user's queries, event detection for detecting the farming field's activities, a mobile application for smart device users to control and manage the farming activities, and dashboard for real-time monitoring. Once the data is collected from the farming field, they have implemented a web server and web server database to store those data and streaming data for real-time monitoring. With the help of sensing data, they have introduced some algorithm to the temperature sensor to get the accurate value according to the developer's threshold value.

In the modern world, technology is growing fast, according to new techniques and methods. With the development of IoT technology in farming activities [12], this researcher has introduced a new concept for the smart farming environment with the greenhouse concept. With this concept, they have used the edge and cloud computing, which provide more flexibility to the proposed system with data streaming and transferring. In this system, the sensors, actuators are connected to the GPS nodes. They use some sensors, such as solar radiation, humidity, temperature, ph meter, flow meters, and pressure sensors. Actuators are used in the system, such as soil and water nutrition pumps, valves, and activation devices. All the sensor devices are connected to the GPS device through the wired technology, and those GPS devices are connected to the internet through the wireless network called, 6LowPAN model. According to the connected devices to the proposed system, the edge plane is placed near the cloud platform, and virtualization helps this process for these researchers. They have used electric panels installed to the greenhouse to control the greenhouse condition according to the sensing data.

[11] According to this research paper, researchers have implemented a smart farm concept that collects field readings from the sensors and controls those environmental factors and traceability systems to monitor real-time activities in the farming environment. This research has used a cloud platform to connect every device and data transferring and data streaming. They have introduced a cloud platform called "Netpie" to get together all the devices together. They have also developed a smart dashboard and mobile application for smart farming users to control farming activities and monitor real-time feeding. The same as previous research, they have used some sensors to gather environmental factors such as humidity, water temperature, air temperature, and pH value.

III. Analysis/Findings

What system is going to implement in this research project is discussed in this section, what kind of techniques that need to use, what kind of networking techniques are going to use, how it can collect the sensing data, what kind of devices need in this implementation and how it can monitor the real-time environment.

Table 1: Comparison of the methods use in the different researches

No	Author/ Year	IOT verticals	Data collection	Technology used	Benefits (Proposed system)	Challenges in existing system	Solution provided
01	Konlakorn 2018 [2]	Smart farming.	✓ Temperature ✓ Soil moisture ✓ Humidity ✓ pH value ✓ EC value	✓ Mobile technology ✓ Wi-Fi ✓ Cloud computing	✓ Can measure the temperature, soil moisture, humidity, and pH and EC values.	✓ Human interaction ✓ Water wastage	✓ Auto dosing system ✓ Foggy spray system ✓ Traceability system
02	Deden 2019 [7]	Water management.	✓ Soil moisture	✓ Wi-Fi	✓ Real time soil moisture monitoring ✓ Remotely access the data.	✓ Water wastage. ✓ Low or high watering	✓ Real time monitoring system. ✓ Smart dashboard.
03	Ashifuddin 2018 [8]	Smart farming. Field management.	✓ Temperature ✓ Soil moisture	✓ Arduino ✓ Cloud computing ✓ Wi-Fi	✓ Can detect the temperature, soil moisture. ✓ Lessen the human intercession ✓ Control the high voltage electric equipment. ✓ Store data for future works.	✓ Human interaction ✓ Water wastage	✓ Field monitoring system. ✓ Cloud platform storage for future work. ✓
04	Andreas 2016 [9]	Smart farming. Pest management.	✓ Temperature ✓ Soil moisture ✓ Event detection	✓ Wi-Fi ✓ Mobile technology	✓ Real time event detection. ✓ Soil monitoring ✓ Temperature monitoring.	✓ Crop wastage ✓ Decision taking issues.	✓ Smart dashboard ✓ Mobile application ✓ Event detection system
05	Miguel 2018 [10]	Precision farming.	✓ Temperature ✓ Humidity ✓ Soil moisture ✓ pH value	✓ Wi-Fi ✓ Cloud computing ✓ Edge computing ✓ 6LoWPAN ✓ Digital/analog IO connection	✓ Monitor temperature, soil moisture, humidity and pH value. ✓ Utilize the water usage ✓ Electricity saving	✓ Water wastage ✓ Crop wastage	✓ Crop management system. ✓ System for precision agriculture

A. Proposing new system schemas

- Soil moisture measuring system

In the purposed system, I am supposed to implement a soil moisture measuring system to measure the moisture level in the soil in the farming field. In the modern world, the smart concept is used in everywhere, so when it comes to farming concept, it needs to think about, how it can convert the farming environment to the smart environment. For doing that conversion, it needs to consider the existing systems that develop with the internet of things (IoT) devices. So, in here, measuring the moisture level in the soil, it needs soil moisture sensor, wireless sensor network to connect the sensor, XBee module (RF transceiver) to transfer the data to central server and microcontroller (Arduino).

In this proposed system, it mainly focused on the soil moisture measuring system in the smart farm environment. [14] Typically, with modern technology and modern generations, most of the peoples, are not interested in working in the farm field. So automated soil moisture measuring system is necessary for the proposed smart farming system. With the help of soil moisture measuring sensor, it collects the data from the farm field, and it sends to the central server through WSU (wireless sensor unit). Then the collected data compared with an inbuilt threshold value. Then, if the collected value is lower than the threshold value, it needs to send a signal to actuators through WIU (Wireless information unit) to turn on the watering system for the farm field. If the collected value is higher than the threshold value, it needs to send another signal to WSU (Wireless sensor unit) to continue the process till it found lower value than the threshold value.

- Wireless sensor network

In the smart farming design, [13][15] the wireless sensor unit (WSU) is the fundamental unit which used to transfer the data to the central database, and also it connects all sensor units in the mainboard (Arduino).

- Wireless Information unit

When talking about the smart farming concept, it needs to communicate between the central server and the wireless sensor unit. The wireless information unit implemented to communicate between the central server and the wireless sensor unit.

- Temperature monitoring system

To monitor the temperature of the proposed system in the smart farming environment, it needs to use the temperature sensor probe, which provides real-time temperature values to the central server. With the help of temperature monitoring, it can maintain and control the temperature level in the farming environment.

- Real time monitoring system for the both soil moisture and temperature.

To get the accurate result, in this purposed system, it has purposed a mechanism to monitor the real-time data feeding of the soil moisture and temperature sensors. It will provide a good outcome for the system architecture. Because with the help of a real-time monitoring system, it can manage and control the water level and temperature of the farming environment. It will be an extra benefit for the smart farming concept.

- Purposed mobile application to farmers.

In this smart farming concept, it is vital to purposed a mobile application to the farmers who are using smart devices to their farming activities. With the help of this mobile application, farmers can check the water level, temperature level, moisture level in the soil. Also, they can control the threshold value for every sensing unit using the mobile application.

- Sensor monitoring system.

In the existing systems, [16] there are some sensor monitoring systems has been proposed and they are monitoring the sensor productivity only, in this purposed system, it will monitor the sensor productivity, real-time sensing activity and real-time data parsing process through the particular sensor will be monitor. The sensor monitoring system only provides access to its developers only. Otherwise, it will be a security issue for the entire smart farming system.

The below table will show how the sensor monitoring system works and what kind of usage it provides to the system.

Table 2: How the sensor monitoring system works and what are the usages from those monitoring to the system

Sensor Unit	Attribute that can be monitor using particular sensor unit	Benefit of monitoring the sensor.
• Soil moisture sensor	• Moisture level of the soil	• It can identify the sensor reading errors. • It can identify the connectivity errors to the wireless sensor network.
• Temperature sensor probe	• Temperature level of the smart farming environment.	• Identify the sensing data errors. • It can identify the sensor connectivity issues before complete system run.
• Water level monitoring sensor.	• Water level of the farming field.	• Whether it provides accurate readings to the main board. • Identify the sensor connectivity issues.

- Proposed smart dashboard

With the modern world, everything needs to be smart. For this smart concept, a smart dashboard is a more reliable and flexible mechanism to increase user interaction. Anyone who needs to access the smart farm features it can access the smart dashboard with a proper authentication mechanism. For the smart farming concept, it is essential to purpose a smart dashboard concept with the real-time data monitoring, data controlling and managing the water level, the temperature level of the purposed system. Also, it includes the real-time sensor monitoring system as well. With those features, the smart dashboard to the smart farming concept, users and other clients can access according to their requirements.

B. Research findings

Table 3: Research findings

CONCLUSION

This report described the smart farm and monitoring system for the environmental condition using a wireless sensor network. With the use of the wireless sensor network and IoT based sensors, it collects the environmental conditions, such as temperature, soil moisture. It uses the wireless sensor network to connect all the IoT devices. When collect reading from sensors, it needs to keep all sensors working correctly.

To monitor the sensor connectivity, it also proposes a system to monitor each sensor in the smart farm system. To provide a better outcome for the users, it has proposed a smart dashboard to control and manage the smart farm system. It can be managed and control remotely. Also, it proposed a mobile application for the smart device's users that can check the weather condition with one click.

No	Techniques/mechanism	IOT verticals	Results/outcome
[1]	WSN server model for smart farming.	Water management	✓ Implementing the WSN in farm field to measure the moisture of the farm field. ✓ Reduce the time that spent to measure the moisture of the farm field
[2]	IOT based smart farming to control high voltage electrical devices	Smart farming	✓ High precision crop control. ✓ Control different actuators and farming equipment without human interaction. ✓ Low cost and high access rate networking form
[3]	AgriTalk: IOT platform.	Precision farming	✓ Provide quick respond to dynamic change of the field environment. ✓ Flexible and efficiency irrigation and pest control system for farmers with remotely managing access.
[4]	IOT architecture for sensor data collection	Crop management, smart farming	✓ Poly house mechanism for crop production efficiency. ✓ Algorithm for soil moisture sensor and temperature sensor to get the accurate result.
[5]	Aeroponic system with intelligent sensor techniques.	Smart farming	✓ Existence of aeroponic system can allow producing food whole year without interval.
[6]	AgriIOT Semantic framework	Smart farming	✓ Integrate multiple cross domain data streams with flexible and extensible ✓ Providing semantic processing pipeline.
[7]	NETPIE cloud platform to interconnect every IOT devices together.	Smart farming	✓ Traceability system to increase the confidence level of customer when buying the agricultural product. ✓ Algorithm for auto dosing system.
[8]	Network infrastructure based on IOT	Smart farming	✓ Minimizing the energy requirement by miniaturization the devices.
[9]	Precision agriculture platform	Crop management	✓ Low cost exchangeable hardware ✓ Three tier open source software platform (local, edge, cloud)
[10]	SmartFarmNet IOT platform	Crop management	✓ Automate the collection of environmental, soil, fertilization, and irrigation data. ✓ Automatically correlate such data and filter-out invalid data from the perspective of assessing crop performance. ✓ Compute crop forecasts and personalized crop recommendations for any particular farm.
[12]	Scalable network architecture	Smart farming	✓ Reduce the network latency. ✓ Cross layer-based channel access and routing solution for sensing. ✓ 6LoWPAN used for efficiency routing. ✓ WiLD network for longer distance ranges with less delay.

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