Viability Ground Tests to Predict Reliability and Fidelity in Crop Growing with the Devices and Applications of the Internet of Things

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Abstract

The accurate prediction in the field of agriculture is essential for the challenges like shortage for food, deterioration of soil properties and water scarcity. The developments in modern communication protocols and wireless communication standards help to build up accuracy in the smart agriculture. Internet of things technology has brought greater revolution to the common farmer's life by making everything intelligent and advanced. The IOT self-configuring network enhances agriculture production and crop yields by reducing the wastages and cost. The proposed technology is integrated with arduino technology breadboard mixed with various sensors. Sensors are used to observe ambient temperature, atmospheric humidity, soil electric conductivity, Soil moisture level, Soil status, soil temperature, PH level and Luminance. The intelligent perception system, intelligent process and control system allow farmers to obtain detailed data on real time as variables for the above measures. Wireless sensor networks are used for communicating these data with the help of Artificial Intelligence system. There are various wireless sensor network technologies such as Narrow band Internet of things (NB-IOT), long range (LoRa), Zigbee wireless communication, LTE-M are used to measure and monitor the field agriculture scenarios. There are many smart devices which help the farmers to monitor their crops, atmospheric humidity, and soil conditions to make reasonable decisions. This paper attempts to experiment various field tests to find the precision in farming and agriculture. It is tested on live agriculture fields giving high precision over 98% in data fields.

Keywords: IOT Based smart farming architecture, Sensors, Methodology and Experimentation results, Implementation challenges, Advantages of 5g on smart farming

Introduction

From the studies of food and agriculture organization of the United Nations (FAO), the world's population estimation will reach 9.2 billion by 2050. Due to this there will be scarcity in water resources, fertile lands and farming. Moreover, there will be decrease in agricultural labour force, various technologies such as sensor technology, Environment friendly farming through flexible fertilization technology, ICT information and communications technology, Geographic information systems are shaken their hands to increase the productivity even with a small labour force. The innovative ideas behind these technologies help to promote optimum production in the agriculture sector. By reducing the fertilizer usages and environmental impacts the productivity is increased to achieve maximum profits. There are many smart devices which help the farmers to monitor their crops, atmospheric humidity, and soil conditions to make reasonable decisions.[1]. Also, these AI systems help to minimize the wastage of pesticides to control the pests, diseases and weeds effectively, thereby leading to a green farming. The wireless communication network is comprised of three varieties of applications based on the transmission distance, Short-range, Medium distance and Long-Range technologies. Bluetooth and Ultra-wideband are short range wireless communication technologies which transmits the data below the distance 10m. Wi-Fi and Zigbee technologies are medium- distance technologies pass the data in between the ranges from 10m to 100m [2]. The cellular networks such as 2G/3G/4G and LPWA and its applications are long distance wireless communication technologies. In recent years several LPWA methodologies like LoRa, NB-IOT and sig Fox have emerged. Lora and NB-IOT offers more than 15km distance range at acceptable data rate with about 100mw power consumption

IOT Based Smart Farming Architecture

To construct this architecture various sensors such as temperature sensor, humidity sensor, Light sensor, soil sensor, Moisture sensors may be used. Depending upon the requirements of the farmers the above sensors are used to monitor the crop field and intellectualize farmland management. Wireless sensor network protocols are applied to collect the data. Also, it is responsible for processing the data [3]. The sensors, actuators or end devices are the foundations of this farming system. It is used to observe the farming field to collect the information which is to be further processed. Local Gateways or base stations are connected further to provide extended functionality. It provides required connectivity, interactivity and security. The network server or cloud server provides data storage, data analysis and data processing and database management services. Also, it supports intelligent decision making. The communication technologies such as LoRa, NBIot and Zigbee are used for precision agriculture [4]. The application network server receives data, visualize data and it's also responsible for storing data. The WSN terminals are responsible for transmitting the sensing data through transmission network. The WSN communication modules consist of a transmitter and a receiver. The main function of transmitter is to upload the sensing data to the gateway and the receiver receives the command messages from the gateway. In such a way, gateways are only bidirectional relays (or) protocol converters and they forward raw data frames.

Methodology

To construct this architecture various sensors such as temperature sensor, humidity sensor, light sensor, soil sensor and moisture sensor are required. Depending upon the requirements of the farmers, the above sensors are used to monitor the crop field and intellectualize farmland management. Wireless sensor network protocols are a group of spatially dispersed and dedicated sensor protocols and they are used to monitor and record the physical conditions of the environment. [5]. They are collectively passed on such data through a wireless network to a internet-based location. Wireless Sensor Networks (WSNs) are subtype of broader IoT networks. WSN consists of wireless interconnected networks of small low-power sensor devices. These devices sense some environmental parameters at regular intervals of time and send them over to some central storage or databases which are fog or cloud across the Internet. WSN protocols maximize the performance of the sensor nodes. Also, they minimize the latency of communication and they reduce the consumption of power [6]. The Wireless Sensor Networks span across various fields of agriculture in which a hardware prototype is used for intruder detection. It helps to generate alarms in the farmer's house and at the same time transmits a text message to the farmer's cell phone when an intruder enters into the field. To implement this scheme, An Advanced Virtual RISC (AVR) microcontroller-based wireless sensor boards over an outdoor environment is implemented to evaluate the performance [7].

Table 1 Comparative Study of Various Communication Protocols

Measures	Bluetooth	Zigbee	Wi-Fi	Lora	NB-IOT
Public/Private	Private	Private	Private	Both Public & Private	Public wireless protocols
Topology	Mesh	Mesh	Limited Mesh topology support	Star topology	Star-Based
Power consumption	Very low Consumption	Low power Consumption	High power Consumption	Low power Consumption	Ultra-Low power Consumption
Smart phone support	Full support	Supports the smart phone	Full support	Android iOS smart phone support	Higher bandwidth and mobile connections including voice

Implementation Challenges

It is difficult to integrate various data observed from different sensors used in IOT with smart farming. The information exchange depends on the connectivity and standards used with IOT communication protocols. If devices from different manufactures do not use the same standards interoperability is quite different process. It may require extra gateways to transfer from one to another [8]. Massive data are stored in the large repository, technologies like cloud computing and fog computing to store large amount of data. The data exchange between IOT device and database or cloud is major issue sometimes poor internet connectivity is observed in agriculture farms, since most of the farms are situated in remote area.[9][10]. The required internet speed is not retrieved moreover communication lines are distracted by crops, weather conditions wind, storm, and monsoon barriers also some physical barriers. Sometimes the signal strength and signal interference may be weak in the field. Due to the weak signal the expected outcome will not occur. The 5G technologies can solve this problem in future [11][12].Selecting the proper hardware and right software tools and technique is a big issue in farming, the reliability accuracy and precision measures depend on the quality of sensors and powerful data analytical tools, sometimes the sensors placed on the agriculture field are affected by animals, birds, rain, and storms etc., also limited access of memory is used in these devices [13].Since huge volume of data is stored, the data theft and hacking is carried out since many farms use drones to transmit data. Since the IOT devices are damaged by birds, Animals and other intruders, the replacement of these devices is required. The repair work and maintenance are quite expensive.[14].

Proposed System

LDR (Light dependent resistor) is used to sense the light intensity of the agricultural form. When the light intensity is low in the farm, LDR Monitor turns ON the bulb. The bulb will then OFF after receiving the required high intensity. IR sensor is used to detect the pests and birds. These sensors are the interface to process Arduino-UNO. The LCD monitor displays the status of various sensors. The sensors detect the change in the temperature condition and turns ON the DC. After the temperature comes to the normal position, the DC fan will turn OFF. The soil moisture detector senses the water levels in the farm field. When the ground is dry, it turns ON and DC pumps the water in the ground. When the farm gets enough water and moisturized, the DC water pump will turn OFF. The farmer can observe and monitor these actions using their mobile phones, if it is connected with the help of Wi-Fi module through IOT devices and IOT based applications. The Arduino integrated development environment (IDE) is a cross-platform application. It is written in the java programming language and it can be executed in windows, MAC, OS, LINUX environment. The IOT application system consists of the following main modules like temperature reading module, Moisture reading module, Lights ON/OFF module, and Fan ON/OFF module.

Experimental Result

The humidity sensors and soil moisture sensors were connected with the system. The UBUNTU 14.04.03 operating system connected with arduino IDE is used to observe the farm fields. Soil moisturizer sensor is used to find out the status of the soil in the agriculture field. Based on the moisture level the connected pumps are activated to pass the water in the field. It will be useful to save the water.

Fig: 1 Soil moisturizer Sensors

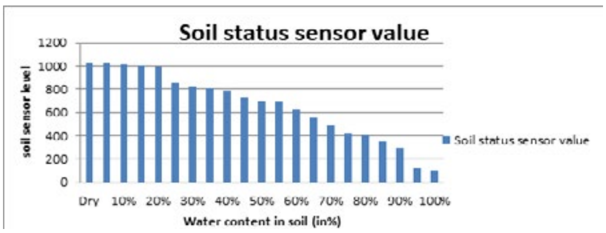

Fig2: Soil moisturizer sensor displays the status of the original soil

The ambient temperature, atmospheric humidity, soil temperature and soil moisture are observed for every one hour and the chart is drawn based on the readings. Since Samsung and Motorola had phones with thermometers. Samsung Galaxy S10 and Note 10are used to calculate ambient temperature.

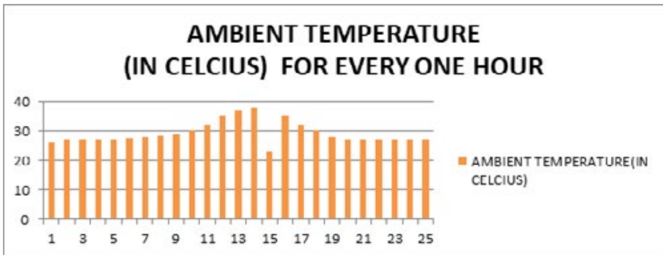

Fig 3: Ambient temperature

On newer Samsung phones such as Galaxy S10, Note 10, and Galaxy S20 can able to detect moisture and find a water drop icon is seen in the status bar and a notification from Android System can also be received. Smart Humidity Sensor allows growers and farmers to know about the total water usage per irrigation, week, month, Hour and season. It also displays real-time data to help farmers reduce workforce and thus reduces the electric power consumption. Henceforth cost is also decreased.

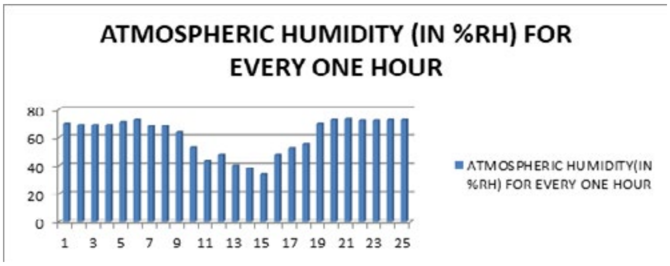

Fig 4: Atmospheric Humidity

Temperature sensors are used to observe the soil temperature. Temperature sensors send out alerts or texts whenever an equipment system requires minor maintenance, is underperforming, or is critically failing. The standard digital thermometer can test the soil temperature readings. Before using a thermometer for soil give probe a good rinse and dry it thoroughly. The soil temperature around 45°F to 70°F (7° C - 21° C) is to be maintained for the successful plant growth [15][16].

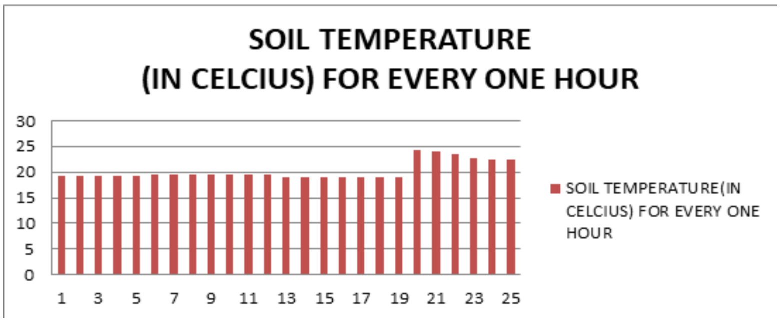

Fig 5: Soil Temperature

Soil moisture content is observed and cooler parameters were examined using scatter plots. The critical soil moisture content was determined based on the change in distribution of color in the soil. The images of the soil samples were pre-processed to account for differences in illumination

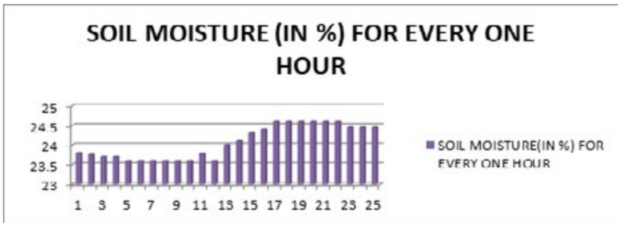

Fig 6: Soil Moisture

The sugarcane is a tropical plant that produces well in areas where the air temperature is between 18 and 38 °C. The average relative humidity 40-80% and a minimum of 1,200 mm to 2,500 mm rainfall are required.

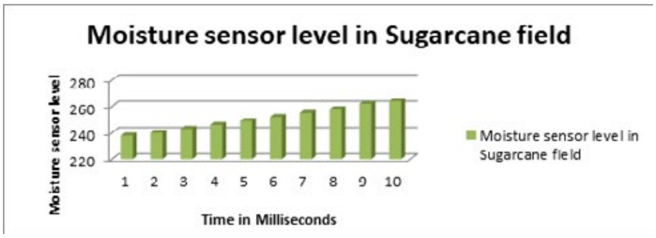

Fig 7: Moisture sensor level in sugarcane farms

Rice crop grows well in a hot and humid climate and it is best suited to regions which have high humidity. The prolonged sunshine and an assured supply of water are essential for the growth of this plant. The average temperature required throughout the life period of the paddy crop ranges from 21º C to 37º C. The optimum relative humidity for rice cultivation lies between 60% and 80%.

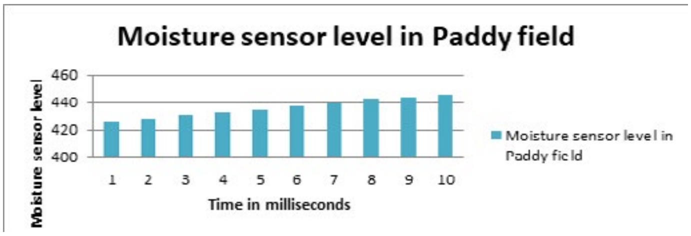

Fig 8: Moisture sensor level in Paddy farms

Banana is basically a tropical crop and it grows well in the temperature below 38° C. Banana farm is observed with the soil moisture sensor with relative humidity 56% at the temperature 36.5 produces the following result which is depicted in the chart as given below.

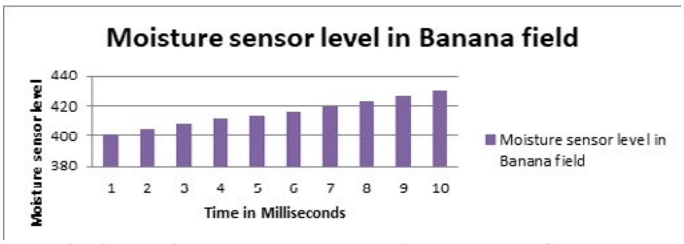

Fig 9: Moisture sensor level in Banana Garden

Groundnut field is observed with the soil moisture sensor with relative humidity 50% at the temperature 33.5 produces the following result which is depicted in the chart as given below.

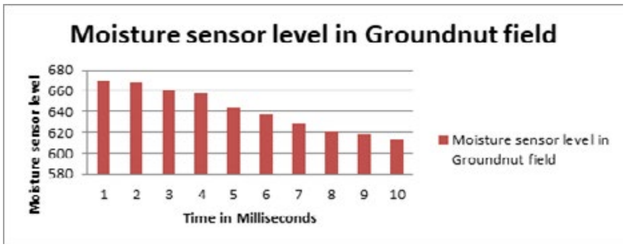

Fig 10: Moisture sensor level in Groundnut farms

5G On Smart Farming

During the past ten years, the 3G/4G/NB-IOT wireless network technology helped in transferring information and increased the speed of communication. With the connection of smart devices through IOT, there were many drawbacks to share data for accurate evaluation in the agriculture field and therefore the efficiency of 4G networks has decreased slowly. The fifth-generation communication network which is named as 5G provides very high speed to transform the data in less time. The download and upload speed is also increased compared to 4G network. In 5G network technology, the spectral efficiency and data transfer capacity is high and it is improved. There is also high efficiency in network energy and smooth communication performance in this type of network. Moreover, it has extensive coverage [17]. Autonomous tractors and drones are also embedded to improve the performance of crop harvesting, seed operations, pesticide and fertilizer spraying. It can also be done with artificial intelligence robots. Interactive real time monitoring process is applied with drone control and robot control. Unmanned Aerial Vehicles (UAVs), commonly referred to as drones are making waves in the agricultural industry. It provides smart farming solutions that use real-time data gathering and processing to improve farm-wide decision-making and efficiency. It frees up time and money needed elsewhere within farm businesses [18][19]. Examples of drone applications are field irrigation, monitoring crop health seeding and planting fertilizer, and pesticides spraying, crop inspection for pests and soil analysis. In addition to drone control, it is equipped with 3D cameras; thermal, multispectral and optical imaging cameras can be used to monitor crop conditions and diseases, plant count, fruit size, field water management, vegetable density, nitrogen measurement and so on. The IOT robots can perform many functions instead of humans. Because of usage of robots the efficiency in agriculture is improved. The operating costs and operating time are reduced in these types of robots. It can reduce the environmental pollution up to 80% of farm's pesticides [20]. The Fog computing is relatively a new paradigm in computing domain. It can successfully augment cloud computing model with more environment friendly technology. It also plays a pivotal role in the growth of smart agriculture due to its small carbon foot print. Fog computing is a decentralized computing structure. It brings processing, storage and intelligence control to the proximity of the data services. It extends cloud services to the edge of the network and therefore reduces the distance across the network. Moreover, it improves efficiency and the amount of data needed to transport to the cloud for processing analysis and storage.

Conclusion

The IOT in smart farming proposals must be universal that means it can be used for any crop in any agriculture field. The water supply and plantation of crop based on the data collected from the various sensors which are connected to the ground level of the farm field. According to this paper 98% of precision is calculated based on the input data. IoT in smart agriculture uses robots, drones, remote sensors, and computer imaging combined with continuously progressing machine learning and analytical tools for monitoring crops, surveying, and mapping the fields. It sends data to farmers for rational farm management plans to save both time and money. Because of usage of smart technologies in agriculture field, it helps to provide precision farming, livestock monitoring, climatic conditions monitoring and so on.

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