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PREDICTION OF CROP YIELD IN PRECISION AGRICULTURE USING MACHINE LEARNING METHODS

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ABSTRACT

Crop yield estimationis crucial in agriculture. Remote sensing (RS) methods are rapidly being employed in the creation of decision support systems for modern agricultural systems to boost crop output and nitrogen control while lowering operating expenses and environmental impact. However, because RS-based systems require the processing of large amounts of remote sensing - based data from a variety of platforms, machine learning (ML) techniques are gaining popularity. This is owing to the ability of ML algorithms to handle non-linear problems and a large number of data. Over the last 15 years, there have been significant breakthroughs in machine learning-based methods for reliable crop production. Rapid advances in sensor technology and ML methodologies, according to the study, will provide cost-effective and extensive solutions for improved crop and ecological status estimations and decision making. In the near future, more targeted application of sensor platforms and machine learning techniques, the fusion of different sensor modalities and expert knowledge, and the development of hybrid systems combining different ML and signal processing techniques are likely to be included in precision agriculture (PA).

Keywords: Vegetation indices, Features extraction, Predictive modelling, Decision making Information fusion.

INTRODUCTION

The idea of the global network was rapidly stretching its wings in every part of life over the last few years. For researchers, determining the ideal capacity of Web usage has become a difficult task. The name Internet has come to be linked with objects, and it is known as the Internet of things applications Things are connected to the Bluetooth, NFC, Long-Term Evolution (LTE), Internet via WSN, RFID, and other smart multimedia applications, as the title suggests. As a result, the Internet of Objects (IoT) might be considered as "things that are connected over the Internet." This connection aids in the transmission of data collected from different devices to specified locations over the Internet. In such a difficult situation, the purpose of this essay is to aid all those who want a simple and thorough approach to understanding the concept, as well as those who want to contribute to its conversion so that it can serve in the best possible way.

There is little doubt that precision agriculture is a viable answer to issues like population expansion, food scarcity, soil deterioration, and water shortages. Furthermore, PA can reduce pesticide waste while successfully controlling pests, illnesses, and weeds, as well as ensuring that yields receive sufficient nutrients, resulting in sustainable agriculture, efficiency, and green. As previously said, the deployment of precision farming necessitates the use of numerous modern information technologies. To effectively connect current wireless devices with PA, everyone must grasp the features of farming and the digital telecommunication application scenario in agriculture. This article examines the web-based systems used in agriculture, emphasizing energy consumption, communication distance, and other concerns. These are the important factors and concerns in the real implementation of wireless technology to farming in the method of transferring information. This research seeks to develop efficient and best wireless communication solutions for PA applications by analyzing a variety of wireless technology and agricultural activity scenarios.

Related work

High-Level IoT Architectures

This category contains all of the suggested IoT architectures in the literature. [2] presents a taxonomy of generic Communication protocols as well as a top-level generic IoT architecture suitable for smart city applications such as precision agriculture. Similarly, [3] shows a functional picture of an integrated data collecting and smart monitoring system that can be employed in agricultural operations like greenhouses. The authors offer a functional architecture in [4] to encourage the implementation of facility habitat information management systems. To construct a semantically enriched agriculture taxonomy, the authors of [5] combine the recently established Open IoT platform, which is suitable in a variety of use cases, with Digital Farming. However, none of these connected works have been implemented.

Crop Monitoring Platforms

Several Internet of Things (IoT) technologies has been designed for PA management [6]-[8]. A smart farming system was designed to gather crop information and use a production system through correlation analysis between crop statistical data and farming environment data to enhance agricultural production [9]. The portals in [10] and [11] provide and control functionality based on the information being observed.

Irrigation Control Platforms

Several Internets of things solutions has recently been created to control crop water usage. The brief definition developed in [12] is one example. Modern devices, such as the one described in [13], enable users to control the watering system via smart devices. Similarly, the system described in [14] employs cellular technologies to send data from sensors to a database system. The system suggested in [15] uses HTTP to send information to a remote service.

Agricultural application sceneries are often divided into two categories: farming facility and agriculture sector. The agriculture field was distinguished by its vast geographic expanse and difficult territory. As a result, difficulties including data transmission style of nodes, transmission distance, sensor energy consumption, and sensor distribution mode, must be properly examined to acquire appropriate large-scale information survey in the environmental field. [16]. Reliability and sustainability must also be taken into account. In comparison to the agriculture field, the farming facility has the features of flat terrain and a small area, with power usage and transmission distance being the most important considerations. Field sensors capture limited amounts of data, whether in field farming or greenhouses, therefore real-time transfer cost is very low. As a result, precision agricultural wireless communication solutions must have a large number of connections, low power consumption, insensitive delay, long-range, and low data volume.

Proposed methodology

The IoT and WSN are utilized to create the SIS-PAF, which makes use of numerous wireless sensors used in agriculture. This paper proposes a quick expansion of the PA system depend upon Arduino technology and WSN with an IoT network. The purpose of the demonstration is to show how the hardware may be used to make water management decisions for diverse crop areas utilizing continuous control and monitoring, as well as to highlight the accuracy and smart ability of the hardware. The suggested technology combines various WSNs while maintaining multihop communication services in each network module.

PAF with a smart irrigation model

The PAF-SIS is a suggested precision agricultural approach that aims to address the shortcomings of various existing systems for integration. Because water is scarce on our planet, this approach aims to alleviate the problem by reducing the amount of irrigation for depletion. The designed methodology has used IoT devices to coordinate and manage to maintain the farmers restructured regarding the issue of it and use cloud services data which can be secured in the website page. An examined method combines software and hardware devices, with enterprise software including a GSM modem for wireless communication and an Arduino Uno, a moisture sensor. The information acquired by Arduino can be communicated wirelessly via the Hypertext Preprocessor and a GSM modem was utilized to create a website for the farmer in remote places to access all of the parameters. The site is built online and maintains a database of readings from iot communication fed by enterprise software. An irrigation service's pixel value is used to manage sprinklers for different kinds of crops. With this design, only the necessary watering must be provided. IoT-based farming applications have the potential to transform present economic models in the agriculture industry, resulting in higher crop production productivity and better resource utilization. The planning and evaluation of many aspects from afar can be more advantageous to large-scale farmers. Farmers can benefit from the use of IoT-based technologies with the assistance of a network administrator.

To boost crop productivity, the research focuses on large-scale farmers. Farmers may monitor the agriculture unit remotely by using IoT devices to detect heat, water, and moisture. It may be secured in the cloud server. WS, data transfer, energy consumption, core stability, security, and privacy are all features of WSN that allow us to use it in a variety of internet systems. The proposed wireless frameworks are designed to detect moisture before the threshold value is reached, at which point irrigation was converted on until the soil is completely moist. The suggested system is a fully automated system with two phases. There are two methods in the first stage of this method which are used to determine irrigation based on existing objective factors by analyzing existing usual parameters loaded already on the server. The appropriate rate of water supply must be identified in the 2nd phase of the model automated system using ML. Various physical characteristics are taken into account when training machine learning. Mobile software and web-based applications and could be used to control the water pump from a remote place. The system could resemble a compact block with all of the wireless sensors packed inside. The developed scheme may track the plant vertically through an acoustic sensor to measure its development, and then provide the numerical value to the farmer regularly when the plant has grown significantly.

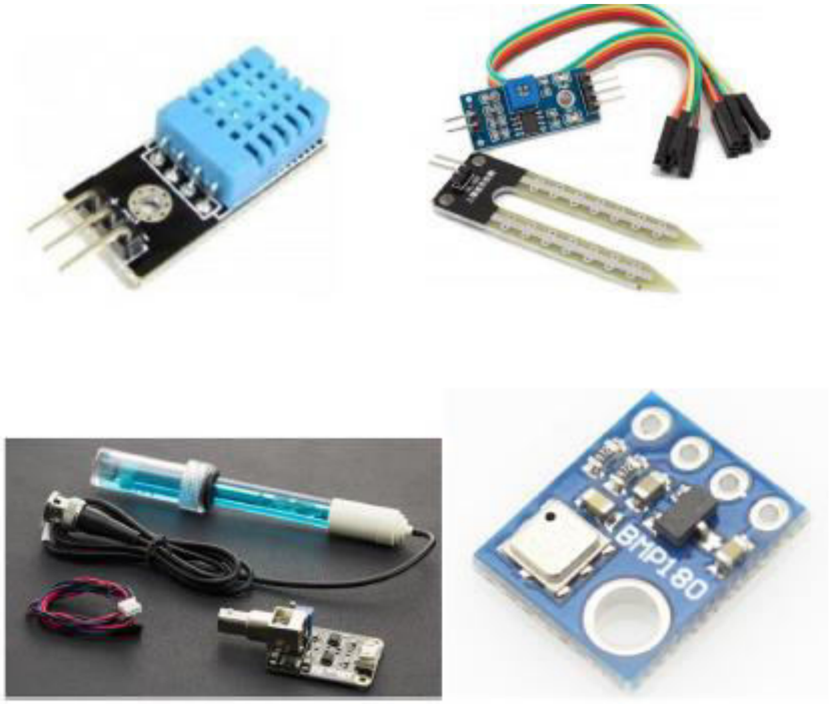

Fig. 1 (A) Arudino's four-pin DHT11; (B) a humidity detector; (C) a PH metre sensor; (D) an atmospheric pressure detector

The overall network management was presented to the agriculturalist since fertilizers and pesticides are applied only on an event to shield the crop, which can have the option to turn off and on in a distinct way where the entire preparation was authorized in measuring the fluctuation in wet content, soil properties, transpiration movement, and photosynthesis. The external humidity and temperature are measured using the DHT11 sensor, which is controlled by a control module inside the sensor. The control unit generates an output that is utilized to switch on and off the complete irrigation system based on the humidity level in the soil. If the moisture level drops too low, the pump motor may need to be turned on automatically. The quantity of current running via the soil is related to the change in humidity. Because they are proportionate, the amount of water passing through the soil determines the changes in humidity. The DHT11 Arduino sensor for monitoring temperature and moisture is shown in Figure 1A. A hygrometer sensor is shown in Figure 1B, which is used to monitor the soil humidity level in the field of agriculture. The PH meter detector is shown in Figure 1C. The pH meter sensor is used to determine how acidic a water solution is due to hydrogen ions. Figure 1D depicts an atmospheric pressure detector used to monitor air compression in an agricultural area.

3.2. Direct Current motor

The Direct Current motor was divided into 2 phases: the receiver and the transmitter. The transmitter component, which is attached to the sensor network, is left on the area to monitor different strictures like humidity and temperature (Figure 2). The centralized server saves the various parameters. Agricultural pumps are stationed at various locations throughout the agriculture field, bringing water to a crop area as needed, as a result of research into different components that are saved in a centralized server at various times since the agriculture field state.

Figure 2 Direct Current motor

3.3. IoT

The IoT was an electronics-oriented integrated system in which sensors, controllers, various forms of software, and network interconnectivity are used to acquire and swap data between actual electronics circuits and devices. IoT's accuracy and efficiency are the major benefits for real-time applications to handle a variety of problems. Agriculture is a major manufacturing application of IoT to use accelerated growth of IoT controller for the overall rate, and subsistence is solely based on agricultural goods.

3.4. CC for Internet of things:

Internet of Thingsdepends CC enables autonomous and access to a pool of equation-based resources stored on a storage server.

1 Communication between a large numbers of hardware devices
2 Availability of computation
3 Providing information privacy and security.
4 Availability of storage
5 Creating a report that is analytical
6 Less expensive

The PAF- SIS uses IoT systems to develop the agriculture site's marketing strategy and increase productivity. In the precision agricultural arena, the Internet of Things adds a new dimension. It is possible to connect agriculture units located in far places correctly and efficiently using cloud computing and broadband extended distance networks in IoT. The PAF-SIS architecture is depicted in Figure 3. The proposed model has the potential to improve PA processes while allowing for better data-driven choice. Agriculturalists can use CC to save and process data by analysis so that the appropriate product accessibility can be selected based on their specific demands. The Arduino Uno is utilized in the routing protocol to operate several applications of WS and other devices, as revealed in fig.3. Extension cords and prototypes are used to connect the detector of soil humidity and water level to the Arduino UNO board; connections are only shown in this section. Relative humidity sensors will detect the stuffiness of the surface, and the data will be sent to sensors via WSN for action. A min and max threshold value has been established, so that the motor will switch on or off instantly when the actual value reaches the predetermined inception value. To display the state of humidity in soil and water pump, an LCD is associated with Arduino and all the detectors. Because this is a little prototype model, a 5 V motor pump was employed, and the Arduino that was used in this design can only give 5 V electricity.

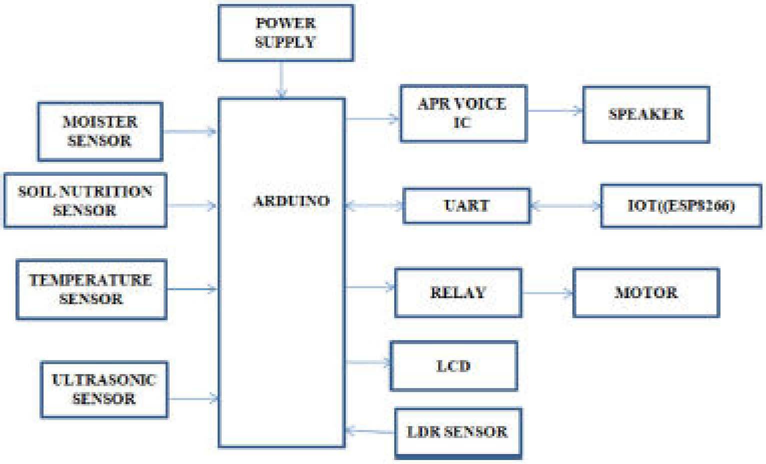

Fig. 3 Smart Water Distribution Design for PA and Farming

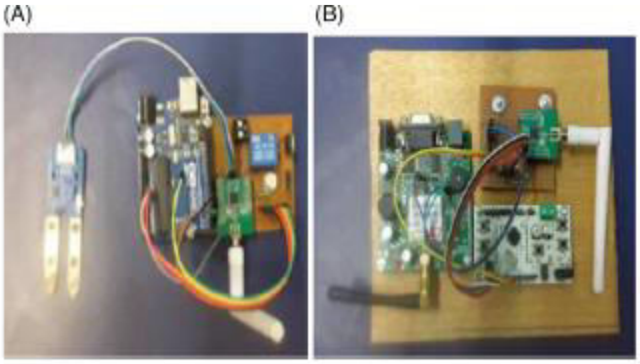

Fig. 4 a) Transmitter unit; b)receiver unit

Agriculture is aimed at a wide range of geographical areas. Multiple areas are desired to boost productivity output by lowering costs and allowing proper delivery and picking to be synchronized.

3.5. An algorithm of problem formulation

(1) Collect information I;
(2) Initiatesmart diagnostic attacks
(3) evaluate the present state of environmental constraints using detector and rules designated as sd;
(4) evaluate the historical state and present state as dsd;

(5) evaluate the historical state, current state and present time as ct;
(6) decide on the current period, which is indicated as sp;

The agriculture sector incorporates transport companies to transfer crops from one place to other agriculture sectors, which includes cost, cultivation, light and water supplementation, selection, and packaging. IoT-based agriculture platforms are extremely strong in terms of transforming present business strategies in the agriculture industry and increasing crop yield profitability through appropriate resource usage (Figure 4).

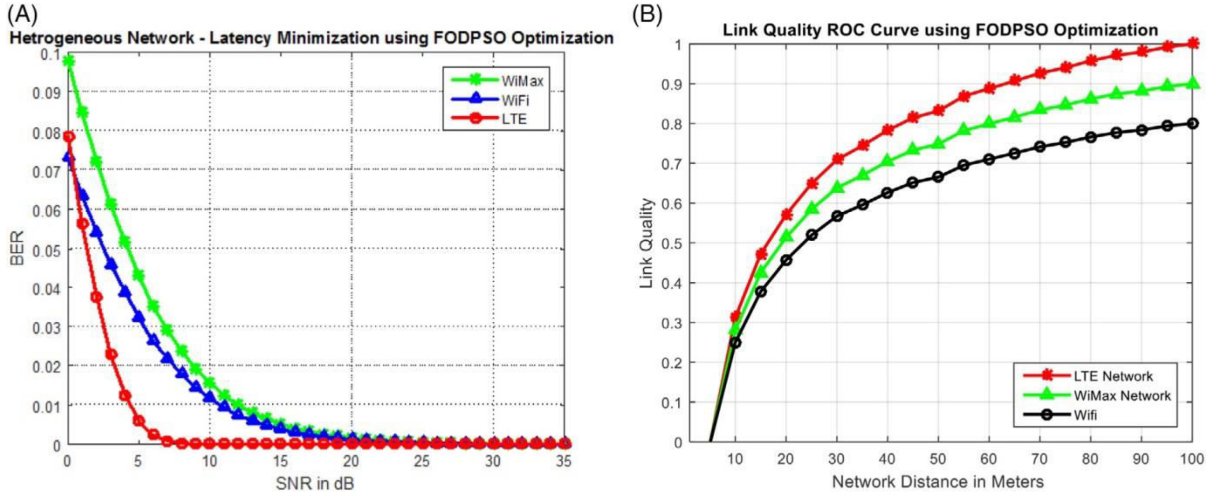

Figure 5A) diverse WSN for precision agricultural production; (B) network performance ROC curve employing variable structure of darwinian optimization algorithm

RESULTS AND DISCUSSION

To develop PA and farming, numerous wireless sensors are integrated with Arduino. The relative humidity parameter is the most important measurement made by a wireless sensor. The irrigation that is preserved in the gaps between distinct soil particles is known as soil moisture. Moisture content is a unique characteristic to estimate when it comes to water management and irrigation quantity. PA and farming water resources comprise the effective, consistent, and targeted use of irrigation to meet the precise requirements of each crop while reducing errors and negative environmental impact. The Internet of Things-based PAF system is used to make choices depending on real-time information gathered from relevant detectors about irrigation requirements. Agriculturalists can use an android application to log on to a website by their password and username. The farmer can then choose from a variety of options on the website to detect and regulate the field of agriculture. Data processing, data sensing, and data transfer to the cloud utilizing IoT are the 3 stages of the proposed system. The wireless detection of physical measurements combining wetness, temperature, moisture, and motion takes place during the information phase. All the devices are connected to the Android R3 integrated circuit, which serves as an IoT gateway capable of sending information to the CC.

A hybrid WSN for PAF is shown in Figure 5A. For various forms of wireless communication networks, the network potential in terms of mistakes was represented as a drop chart. Fig. 5A depicts the various WSN configurations used in PA and farming. The farmer can use WiFi to operate the agricultural unit from the same area. In addition, using IoT based on Wi-Max connectivity, a farmer can operate the farming machine using a smartphone. LTE is a modern communications method that improves data transmission from the transmitter to the receiver. The network (LTE) outperforms other mobile technologies for communication like WiMax and WiFi. LTE was a type of wireless connection that can help with PAF. Fig. 5B demonstrates the activity of the FODPSO method in terms of link quality as measured by the ROC curve. Climate change, such as humidity levels, has a significant impact on agriculture. As a result, all sensitive information must be monitored continuously and correctly communicated to the farmer via a wireless connection, with data being kept in the clone.

The IoT was utilized to connect the agriculture unit and the farmer. The capacity gain in terms of Mbps employing the FODPSO optimization algorithm is shown in Figure 6A. To enhance the system capacity of the data transmission, packet loss is reduced. As illustrated in the graph, LTE performance outperforms WiFi and WiMax. As demonstrated in fig.6B, f- logic was used to ensure that LTE data transmission rates.

The MSE decrease for IoT-based cloud data storage was revealed in fig. 7A. Fig. 7B displays how the FODPSO optimization algorithm improved the SNR in IoT-based CC for a web topology. As a result of the improved general performance of WSNs, the reduction in inaccuracy leads to an increase in SNR.

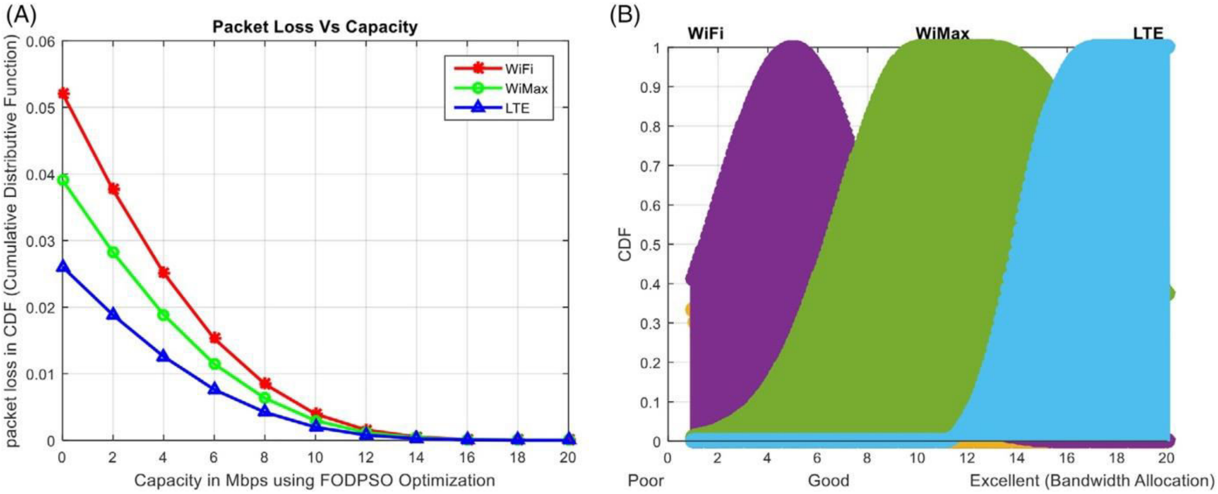

Fig. 6(A) Capacity in megabits per second employing fractional order Darwinian optimization algorithm; (B) performance of different communication devices utilised in PA and farming.

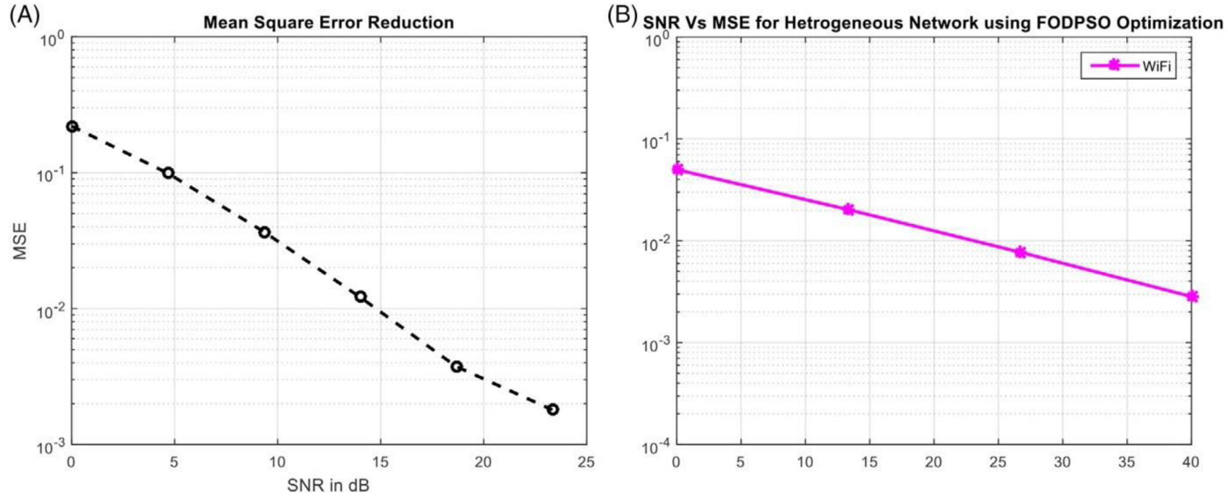

Fig. 7(A) MSE minimization in IoT based cloud storage system (B) SNR enhancement in IoT-based cloud services for routing protocols by fractional order Darwinian optimization algorithm;

As demonstrated in the figures, the optimization process is used to improve all data compiled in a better format. The number of heterogeneous nodes is influenced by two key factors. The first is that the heterogeneous node has considerably fewer combinations than the conventional node, which lowers the overall price of the hybrid network. A large number of diverse nodes lead to significantly enhanced performance and an extended time for the network. The extra aspect was the greater coverage area range. The ideal number of cluster formations will ensure that each standard mode's coverage region has just one hybrid node. The heterogeneous network is used to monitor and regulate the unit over a vast region of agricultural land. Humidity, temperature, and water level are among the agricultural factors communicated over the network topology.

Throughput maximizing utilizing FODPSO optimization IoT cloud computing is shown in Figures 8A, B. Based on its performance, the LTE system has a high throughput rate. Signal strength data for LTE connections are difficult to come by. When dealing with wireless technologies in the past, there was always an unambiguous and immediately accessible metric—the RSSI. When neighboring cells couldn't share frequencies, this metric was useful since it allowed you to credit the system strength directly and confined within single bandwidth to a cell. As channel coding technology has advanced and network operators have produced a large number of compliance standards,

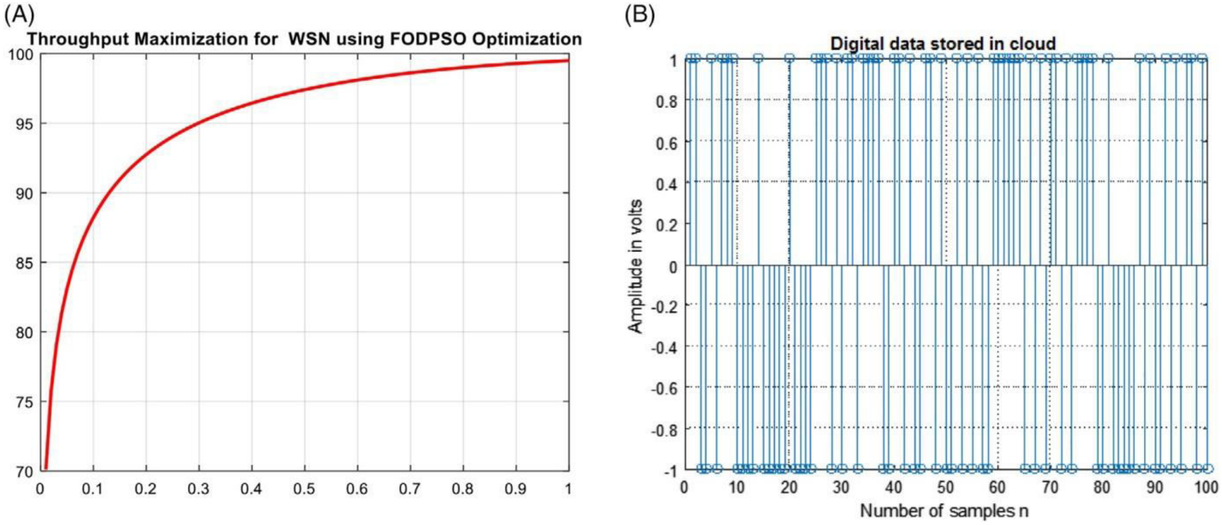

FIG. 8 (A) Throughput optimization for wireless network via fractional order Darwinian optimization algorithm; (B) Cloud storage of electronic information via IoT

Figure 9A depicts the PL valuation for WSN and IoT about the data transmission speed between IoT and WS. In addition to wireless node propagation, the evaluation of packet loss in WSN evaluates link quality via different wireless nodes in the network using link performance degradation. The estimation of the parameter can be used to show how packet loss affects FODPSO routing protocol optimization. The E-E delay computation between velocity and delay is shown in Figure 9B.

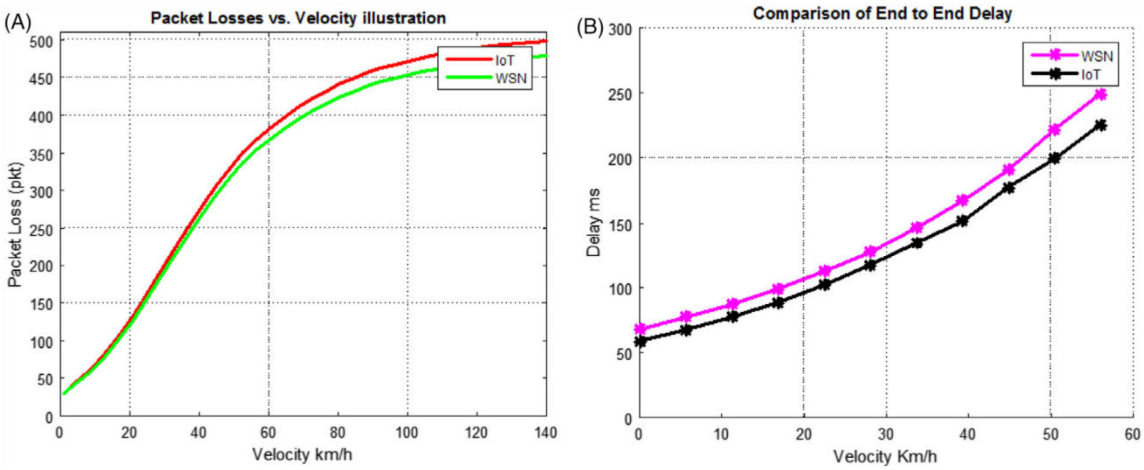

Fig. 9(A) Data transmission velocityVs packet loss for Iot and wireless networks; (B) velocity and delay estimates from E-E delay.

Fig. 10A depicts capacity maximization for Wi-Fi, LTE, and WiMax WSNs. Due to the high bandwidth usage of network node action, the LTE network outperforms WiFi and Wi-Max. Figure 10B depicts the likelihood of detecting a heterogeneous network for IoT cloud wireless communication. Every sensor node calculates and saves data using an exponent weight function to reduce delay about its neighbors. The wireless data routing protocol was chosen for the optimum pathfinding and renewable energy to conserve the power of each sensor node while data is transmitted from one network to another.

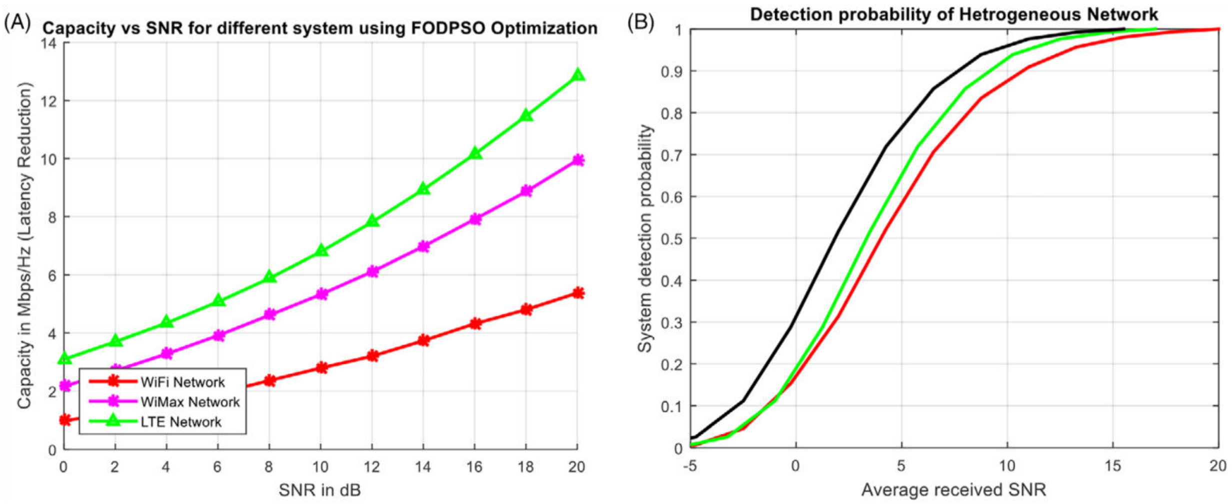

Fig. 10 (A) Optimization for diverse WN; (B) IoT heterogeneous network possibility of detection

The channel network quality for the WSN employing IoT is shown in Figure 11A. In an energy wireless network, the network performance concert is more important since it translates into the lifetime of the network.. WSN is the entire detecting network for different locations. Figure 11B shows how to improve connection quality to increase throughput in a mobile telecommunication system. LTE has the highest throughput of any cellular network.

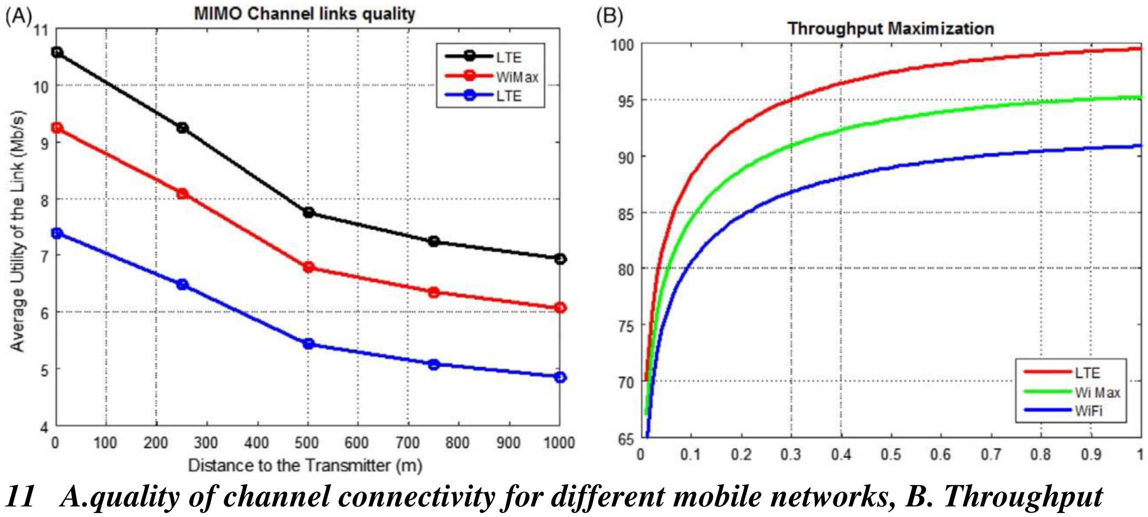

Fig. 11 A.quality of channel connectivity for different mobile networks, B. Throughput optimization

The WSN process in the agriculture industry is shown in Table 1. PF is built on communication and accurate knowledge exchange. Cost, accessibility, energy usage, and security are all important variables to consider when deciding on a communication method. Low potential networks may only connect one site at a time, and most don't offer facilities in rural places.

TAB. 1 Specifications for energy and power for wireless communication communication in farming

Type of data communication	**Application Possibilities**	**Size of Data**	**Depletion of energy**
The size of the data is minimal, and it consumes lesser energy	(1) Air temperature/direction/humidity speed (2) Humidity and temperature of soil (3) Color and thickness of leaf (4) thickness of trunk (5) Size of fruit	100 bytes	Less than a mA
The size of data was medium, and the energy consumption also medium.	(1) Still camera (2)multiple camera (3)Sensors that detect sound	13 megabyte	13Ma
The size of data was large and high energy consumption	Video camera streaming	10s of Mb and minute	50 A

Table 2 shows the senor based data collection. The true aim cannot be achieved unless there was a reliable and secure link in many things. To achieve efficiency and performance in communication, wireless transmission operators may act as an important role in the agriculture industry. If he or she truly wants to integrate the internet of things into the agricultural economy on a wide scale, everyone needs to build a large enough architecture.

TAB. 2 Sensor based data collection

Soil	Tank	Rain	Temp. moisture level	Light
50	0	11	23	51
50	0	12	23	51
51	0	10	22	52
51	0	10	22	52
52	0	9	20	53
52	0	9	20	53
52	0	9	20	53
52	0	9	20	53
60	0	7	19	61
60	0	7	19	61
60	0	7	19	61

Conclusions

Precision agriculture and agricultural systems based on IoT have proven to be incredibly beneficial to farmers, as less irrigation is beneficial to agriculture. Sensor coefficients like temperature, data collecting through sensors, humidity, and wetness could be set dependent on the state of the agriculture field. The proposed approach will create optimal resource usage and solve the problem of irrigation scarcity. An important ability of wireless networks was better represented graphically than prior technologies that could be recovered and statistically analyzed. Precision Agriculture is a practical approach that reduces the risk and variables in agriculture. The growth of technologies in the 21st century led to the development of the PA concept. Precision Agriculture is used for the efficient use of various inputs like effective use of fertilizer, seed, pesticide, fuel, land, data, and water. The agriculture and agricultural industry in a remote area can benefit from the WSN and cloud server-based vast network in the Internet of things.

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