REVIEW ARTICLE

Comprehensive analysis of the sensors used in precision agriculture

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The primary goals of this paper's abstract are to: Increase agricultural production's profitability and product quality and employ sensors to safeguard the environment. The internet of things has made crop monitoring in agriculture simple and effective. The different sensor types that might be utilized to determine the statistical parameters of a field of agriculture, and it provides modern wireless sensor technology and solutions offered for agriculture with Precision (PA). This includes recent data, contemporary sensors and their uses in agriculture. Awareness utilizes wireless sensor network technologies to track vital environmental factors including humidity and temperature as well as lighting. Various kinds of sensors are utilized to gather crop conditions and environmental changes information and the transmission of this information to the conditions of the agricultural field at anytime and anywhere.

Key Words: *Precise agriculture; Remote sensing; Wireless sensor network for agriculture; Smart agriculture, IoT based agriculture; Sensors*

INTRODUCTION

Although industry has played a key part in the Indian economy, agriculture's contribution to the country's economic expansion cannot be discounted. The impact of agriculture on several elements such as labor force, domestic and foreign trade, capital development, agro-based industry, food security for the population, employment creation and national income. Agriculture is unquestionably the foundation of the nation. Precision farming, also known as precision agriculture, is a farm management system that uses information and technology to identify, analyze and manage spatial and temporal variability within fields for maximum productivity and profitability, sustainability, and land resource protection by minimizing production costs. The growing environmental consciousness of the general public requires us to alter agricultural management techniques in order to save natural resources such as water, air, and soil quality while remaining economically lucrative. There are numerous issues with the agricultural sector as well, including unstable crop growth due to dependence on rainwater, lack of farmer knowledge of proper farming methods, inadequate use of technology, poor product marketing, disregard for crop rotation, insufficient use of fertilizers and manure, inability to obtain high-quality seeds, and insufficient water supply.

To overcome this problem in agriculture many researchers has proposed new method of farming that is precision agriculture [1]. Some has proposed on the go soil sensor [2] or some has worked on nitrogen status [3], chlorophyll status [4]. Some has worked on overall precision agriculture scenario [5].

Many of the above given problem of agriculture can be eliminated using the modern technology like sensors. Wireless sensor network is the powerful technology to achieve precision agriculture which provides data that assistances agriculturalists monitor and improve crops, as well as adapt to changing environmental factors. They are widely utilized in a variety of applications, ranging from motion detection in security systems to temperature measurement in HVAC systems. They are also found in daily items including as cellphones, automobiles, and appliances. Sensors detect physical or chemical changes in their surroundings and turn them into electrical impulses. The type of sensor utilized is determined by the sort of change noticed. A temperature sensor, for example, measures temperature changes and turns them into electrical impulses that may be understood by the equipment to which it is linked.

Precision agriculture

Precision agriculture is a method to farm management that practices information technology to guarantee that the crops and soil take exactly what they requirement for finest health and productivity. Farmers, on the other hand, are the ecosystem engineers who discover innovative ways to cultivate crops. Many villages have also established water management strategies to provide water for drinking and other needs throughout the dry season. At the moment, Indian agriculture has the following challenges: Reliance on the monsoon, fragmented land farming and holding, traditional agricultural techniques, insufficient infrastructure in rural regions, and a lack of use of technological applications. Technological advancements will assist farmers in increasing agricultural yield. IoT will be used in a variety of fields, including smart cities, agriculture, energy, environmental protection, health, and home automation. Smart agricultural applications based on IoT include not only the objective of precision agriculture and also to ensure productivity, tolerance and safety of the environment. Precision agriculture supported by Internet of Things (IoT) tools is being implemented in agriculture projects around the globe to improve the potential of the industry.

Advantages

1. No fixed infrastructure is required for setup of the network.
2. Normally inaccessible sites such as the sea, mountains, rural areas, or deep woods can also be used. WSN is used to link devices.
3. It promotes adaptability. As a result, more at any time, a workstation or node can be added. It can accept new gadgets easily.
4. Excessive wiring is eliminated.
5. Infrastructure costs are decreasing.
6. Access to the complete sensor network is possible by the centralized monitor.

Disadvantages

1. It is not very safe since hackers may simply gain access to the access point.
2. The operating speed is slower than that of wired communication networks.
3. Node and network configuration is more complicated than in wired networks.
4. It is easily influenced by its environment. As a result, there are concerns with walls, microwaves, signal attenuation owing to increased distances, and so on.
5. As the number of nodes in the network grows, so does the system's cost.

LITERATURE REVIEW

In this part, we examined the use of sensors in precision agriculture. Bausch et al., offered an overview of certain AI-based data analytics [1]. Strategies

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utilized in many agricultural sensors to reduce labor effort studying a big amount of agricultural data [2]. Ojha et al., compared several wireless sensor technologies.

The following literature illustrates the study issues and relevant information, as well as the drawbacks of past investigations.

Precision agriculture is a management method [2] that uses information technology to collect data from many sources and use it to make decisions about field production operations [3]. The purpose of this strategy is to combine corporate management with process automation concepts. Agriculture 4.0 also brings together several novel approaches used in other industries from time to time, such as the determination of optimal routes for self-driving tractor networks, various wireless sensor platforms, and various agricultural sensors.

Crop monitoring, which is based on direct observations of crops in place to acquire data on phenological phases, nutritional state [4-6], phytosanitary status, production predictions [7,8], and production maps [9,10], is of special importance in doing this. Crop monitoring is based on actual observations of crops in their natural surroundings. Process automation is required because enormous volumes of data must be collected and processed [9].

Crop monitoring takes use of remote sensing data and is based on the relationship that exists between numerous leaf curtain metrics [10]. These measures can reflect plant vegetative-productive responses and assess variability as a function of surface and leaf behavior. Kiani et al., proposed a 10-day weather forecast method. Help farmers organize their upcoming tasks, such as fertilizer, irrigation, and planting.

Singh et al., created several graphs based on temperature against time. Graphs of time and humidity vs. time using the DHT11 humidity sensor deliver an almost exact result with an inaccuracy of only ± 10%. Garg et al., conducted a comparative research of VH400 soil moisture [5]. Volumetric measurements of water content using gravimetric moisture contents for various dielectric equations using a sensor or probe. Bhargava et al., suggested and calculated a measuring technique using accelerated life testing, humidity sensor DHT11 accuracy was 97.52% [6]. Utilizing a variety of artificial intelligence methods within the temperature parameter.

Steps of implementation sensor in farm

The key pillar is the agriculture industry. Many nations' economies, and it merits technical advancement on a shoestring budget. The Internet of Things (IoT) provides a new opportunity, component in the primary soil health monitoring.

1. Sessor Assemble
2. Wireless Sensor Setup
3. Data Acquisition
4. Analytics
5. Result

Types of sensors used in precision agriculture

Moisture sensor: Proper irrigation system gives better crops. It stops excess consumption of water and eventually wastage of water in the farm. It is also helpful irrigators to understand what is happening in the root zone of a crop (Figure 1). Different techniques are being used to check soil moisture like use of gravimetric, nuclear, electromagnetic, densiometric, hygrometric, remote sensing processes etc. It is advantageous to use remote sensing where measurement to be taken over large area and taken for surface soil [7] (Figure 2).

Temperature sensor: Plants need the appropriate ecological conditions for optimal development and health. Temperature affects several processes in soil and soil ecosystem. Because of that, this soil temperature measurement is required. Soil temperature affects: Photosynthesis, respiration, transpiration, water potential of the soil, soil translocation and microbial activity [8]. Diverse sensors can help to monitor and maintain the optimal mix of environmental conditions for plant growth. The LM35 series are accurate integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature.

Weather sensor: An agriculturalist cannot compete the weather. However, he/she can accept the given condition and take added farm management practices to minimize crop losses. Therefore, precise data concerning the weather is important so that farm activities can be prearranged without adverse events. Weather sensor is one of the device through which farmers can abreast themselves with weather condition and its upcoming effects.

Weather sensor accurately measures different outdoor conditions, including the temperature, humidity, wind speed, wind direction and rainfall (Figure 3).

Figure 1) *Moisture sensor*

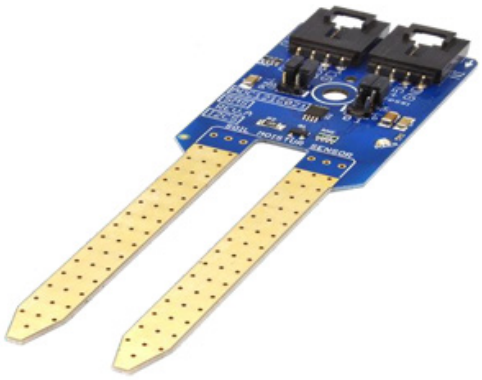

Figure 2) *Soil moisture sensor (National Control Device)*

Figure 3) *Weather sensor (AcuRite)*

Weed detection sensor: Nowadays the food which we are eating is full of chemicals/pesticides. The main aim of using pesticides is to destroy the weeds in the farming land. But the limitation is that the pesticides are sprayed is complete land. So, the land also gets damaged and the nutrition in the food also gets spoiled.

To reduce this, can we detect the weed area to kill them. Ultimately, this is reduction in spraying of pesticide over the plant. Researchers has proposed different technique to do this like image processing, crop canopy mapping, remote sensing etc. Many researchers have proposed ultrasonic sensor for weed detection [9,10]. In this proposed system an ultrasonic sensor was mounted on the front of a tractor, pointing vertically down in the inter-row area, with a control system georeferencing and registering the echoes reflected by the ground or by the various leaf layers. Static measurements were taken at locations with different densities of grasses and broad-leaved weeds. The sensor readings permitted the discrimination of pure stands of grasses (up to 81% success) and pure stands of broad-leaved weeds (up to 99% success).

Fertility sensor: Major nutrients required for fertile soil are Nitrogen (N), Phosphorus (P) and Potassium (K). It is also one of the most useful and informative soil parameters because of its relationship to many aspects of soil fertility and plant growth. Researcher has proposed fertility checker model which give details of all soil nutrient using electrochemical sensor [11]. It gives important information needed for precision agriculture soil nutrient levels and pH. This is not that much accurate which are provided by laboratory test, but high sampling density can increase the accuracy level (Figure 4).

GPS sensor: This sensor is often found in the automotive and cellular communication sectors. They are extremely beneficial to smart agriculture. One important issue that early settler faced was sheep herding, which required them to utilize wooden staffs to move their herds. Farmers prioritize flock tracking since it is critical to their livelihood. Tracking livestock is no longer an issue with the use of contemporary GPS, which is enhanced with the ability to monitor the animals with the easy click of a button.

Leaf wetness sensors: The leaf wetness sensor is an innovative and user-friendly gadget for precisely and inexpensively detecting leaf wetness. Many bacterial and fungal diseases only injure plants when the leaf surface is wet. The sensor detects moisture on a leaf's surface, allowing researchers and producers to predict disease and pests and protect plant canopies (Figure 5).

Application of sensor in agriculture

With the increasing usage of electronic devices such as smartphones and tablets, as well as the availability of internet access, it is relatively simple to share or obtain information from anywhere. Android applications provide rapid and efficient functionality that may be expanded as technology advances. Farmers in areas such as Pennsylvania might benefit more from agriculture monitoring and information exchange applications. Apps for farm monitoring include information such as weather, market prices and availability, and so forth. Similarly, applications can give forecast weather analysis, a selection of seedlings, fertilizers, insecticides, and herbicides and so forth.

Automated irrigation system: Moisture quantity of soils to determine whether a particular soil is moisture deficient or not and helps in planning the irrigation needs of the soil.

Crop production forecasting: Remote sensing is used to forecast the expected crop production and yield over a given area and determine how much of the crop will be harvested under specific conditions.

Figure 4) *Electrochemical sensor*

Figure 5) *Leaf wetness sensors*

Assessment of crop damage and crop progress: It can be used to penetrate the farmland and determine exactly how much of a given crop has been damaged and the progress of the remaining crop in the farm.

Crop acreage estimation: To get estimation of the farmland on which a crop has been planted.

Crop condition assessment and stress detection: Assess the health condition of each crop to determine the quality of the crop.

Identification of planting and harvesting dates: To the weather patterns and the soil types to predict the planting and harvesting seasons of each crop.

Crop yield modelling and estimation: It is used to determine the overall expected yield of the crop.

Identification of pests and disease infestation: It is used for the identification of pests in farmland and gives data on the right pests control mechanism to be used to get rid of the pests and diseases on the farm.

Monitoring crop nutrient deficiency detection: To determine the extent of crop nutrients deficiency and come up with remedies that would increase the nutrients level in crops hence increasing the overall crop yield.

Approach

Precision agriculture is divided into two major categories:

1. 'soft' and 'hard'. 'Soft' PA is mostly based on visual crop and soil monitoring, as well as management decisions based on experience and intuition.
2. Hard factors such as benchmarking and quality measurement, continuous improvement, and efficiency improvement.
3. The soft factors consisting of top management philosophy and supplier support, employee training and increased interaction with employees and customers
4. In terms of the processes and instruments utilized to carry out various management duties, as well as far as the frequency of their applications and their influence on the efficiency of these farms.

CONCLUSION

In this paper, we presented a broad overview of the use of various sensors and sensor technologies especially IoTs and smart sensors have led to the exponential growth in sensor-based applications in agriculture. As agriculture is becoming more data-intensive, these improvements in the technology have helped in the advancement of the area of agriculture. A high percentage of agriculture revenue is lost to power loss, incorrect methods of practicing. This is reduced by the use of smart sensors. Precision agriculture is a clever way of conducting agricultural activities in order to meet the world's expanding need for food, which is made feasible by the use of current technology in precision agriculture. Smart sensors make precision agriculture even more affordable and simple by collecting every agricultural data and using those agricultural details to increase crop output. Precision agriculture makes the most use of resources by utilizing smart sensors. Large and small farms may be watched and managed utilizing technologies integrated into smart phones and agricultural apps. Smaller-sized machines are being developed in order to provide solutions for small farms. This smart technology also addresses global warming, pollution management, and other environmental issues. The number of autonomous agricultural vehicles will grow in the future. Many challenges still remain. However, at large, positive trends were identified, and we conclude that as sensors and data analytic techniques improve, it will bring more insights in solving a wide variety of agricultural issues in precision agriculture.

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