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SENSORS IN PRECISION AGRICULTURE: A SURVEY ON APPLICATION, SECURITY AND PRIVACY

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Abstract

In a developing country like India, agriculture is a prime source of livelihood. But this domain is facing many issues which are affecting the Indian economy. Crop production is the main source of agriculture which was earlier totally depended upon the eye-observation of farmers. So, the invention of Wireless agricultural sensors and Internet of Things (IoT) have come into the present scenario to make intelligent decision making which is called precision agriculture. Precision agriculture is now playing a pivotal role in improved crop production management, water scarcity management etc. with minimum environment threat. In this paper, we have surveyed many technologies involved in precision agriculture and reviewed available agricultural (soil and environment) sensors based on different parameters. We have also discussed security, privacy issues related to agricultural sensors.

1. Introduction

The revolution in the agriculture field has been started from 1980s with the invention of Information Technology. The industrial revolution in

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agriculture has been shown in Table 1[1].

Table 1. Industrial revolution in agriculture.

Year	Tools used in Agriculture
1980-1990	GPS, IT
1990-1994	Satellite & WSN
1994-2000	Mobile, Software
2000 to till now	IOT, Big Data, AI

Discovery of smart wireless sensors and IoT added new feathers in crop production and agriculture field by enabling smart decision system called precision agriculture. During 1990s, the term "precision" was started to apply to the agriculture fields. Now, real-time faultless data is collected through sensors and an emergency alert message is sent to the farmer who accordingly monitors it.

The objective of this paper is to provide a useful manuscript to the researcher about the vision of real-time technologies with smart sensors used in precision agriculture. We have also discussed security, privacy issues in implementing agricultural sensors. In addition, performance analysis of available soil and environment related sensors with respect to different parameters like moisture, temperature, humidity, wind flow etc are incorporated in our paper.

2. Literature Survey

In this section, we surveyed the application of sensors in precision agriculture.

Basnet et al. in [1] presented an overview of some AI-based data analytic methods used in different agricultural sensors for reducing the effort of analyzing a large amount of agricultural data.

Ojha et al. in [2] made a comparison between different wireless sensor networks, different wireless sensor platforms, different agricultural sensors based upon temperature, humidity etc.

Kiani et al. in [3] introduced a 10-day weather forecast system that will help the farmers to schedule next activities like planting, irrigation, fertilization etc.

Singh et al. in [4] have derived some graphs based on temperature Vs time and humidity Vs time using DHT11 humidity sensor and the graphs give an almost accurate result with an error of only ±10%.

Garg et al. in [5] made a comparative study of VH400 soil moisture sensor's or probe's volumetric water content readings with gravimetric moisture contents under different dielectric equations.

Bhargava et al. in [6] proposed a measurement technique and derived 97.52% accuracy of humidity sensor DHT11using accelerated life testing under the parameter temperature using different artificial intelligence techniques.

Matula et al. in [7] made a laboratory performance analysis of five sensors (ThetaProbe ML2x, ECH2O EC-10, ECH2O EC-20, ECH2O EC-5, and ECH2O TE) under Different Bulk Density and Salinity Levels and they found that ECH2O EC-5 and ECH2O TE have better performances in saline conditions.

Giri et al. in [8] proposed an eco-friendly framework Agri Tech which optimizes the agricultural resources and informs the farmer a suitable time for crop planting and selling to gain maximum profit.

Sundareswaran et al. in [9] proposed different agricultural sensors like optical sensor, Location sensor, electrochemical sensor, airflow sensor etc to optimize crop productivity and to reduce cost.

Mat et al. in [10] made a feedback based irrigation system to optimize usage of water and fertilizer by saving 1500 ml water per day per tree.

3. IoT Architecture

IoT architecture is classified as (1) Single-layered (2) Multi-layered architecture. Multi-layered architecture is divided into 4 categories: 1.Three layer 2.4 layer 3.5 layer 4. Service Oriented Architecture (SOA). SOA is the most accepted architecture as it is capable of handling almost all issues like

QoS, reliability, security [11]. Figure 2 depicts SOA with their functionalities [12].

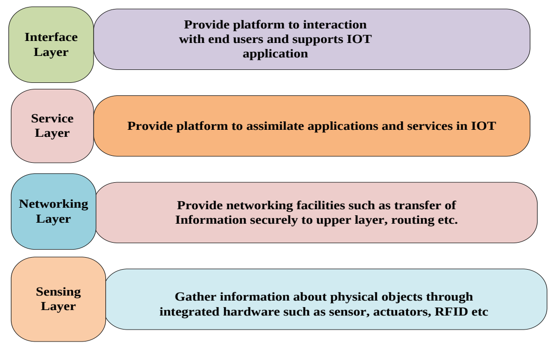

Figure 2. SOA in IoT.

4. Security and Privacy of Agriculture Sensors

Security and privacy become challenges in precision agriculture while implementing agro sensors in the field. With the proliferation of sensors, data privacy and user authentication issues become vulnerable to security threats [8][13]. As IoT and sensors collaborate with each other in presence of internet, network congestion may lead to Denial of Service (DoS) attack. Sometimes, accepting public profile without reading the whole agreement may lead to threat and attack [14]. Countermeasures of the security threats and attacks have been discussed by the researchers [15] [16]. Although no such collaborative solution is present to ensure the security of the agro sensors technologies.

5. Comparative Study of Different Agricultural Sensors

Authors [4] [6] have made different real-time applications based on the agricultural sensors but they have made performance analysis of the sensors based on the only accuracy. But, we have made performance analysis of different agricultural sensors based upon operating temperature range, physical level connected devices, power consumption, accuracy, and cost. Features and performance observation of different agricultural sensors are given in following tables.

Table 2. Different soil sensors with respect to moisture.

Name of the Sensor	ECH2O EC-5 [17]	VH-400 [18]	Pogo portable soil sensor [19]	Hydra probe II soil sensor [20]
Operating temperature range	-40 °C to50 °C	-40ºC to 85ºC	-10°C to +65°C	-10°C to +55°C
Accuracy	3% VWC(Volumetric water content)	2% at 25°C	3% water fraction by volume max in typical soil	3% max for fine textured soils
Power Consumption	10 mA	< 13mA	300mA	30mA
Cost	$115.00	VH400-2M - $39.95	$950.00	$475.00

Table 3. Different soil sensors with respect to temperature.

Name of the Sensor	Pogo portable soil sensor [19]	Hydra probe II soil sensor [20]	THERM200[21]	WET-2[22]
Operating temperature range	-10°C to +65°C	-10°C to +55°C	-40ºC to 85ºC	0 to 50°C
Accuracy	± 0.1°C	± 0.3°C	±0.5°C	± 0.7°C
Power Consumption	300mA	30mA	< 3mA	38 mA
Cost	$950.00	$475.00	THERM200-2M-$33.95	$1299.5

Table 4. Different soil sensors with respect to conductivity and salinity

Name of the Sensor	Pogo portable soil sensor [19]	Hydra probe II soil sensor [20]	WET-2[22]
Operating temperature range	10°C to +65°C	-10°C to +55°C	0 to 50°C
Accuracy	± 2.0	± 2.0	± 0.7
Power Consumption	300mA	30mA	38 mA
Cost	$950.00	$475.00	$1299.5

Observation: It is observed that Hydra probe II soil sensor is the best soil sensor with respect to cost, power consumption, accuracy (in terms of temperature). In addition, this sensor has a flood alarming feature.

Table 5. Different environment sensors with respect to temperature,

humidity and wind speed

Name of the Sensor	WXT520 compact weather station [23]	Met Station One (MSO) weather station [24]	All-In-One (AIO) Weather Sensor [25]	XFAM-115KPASR [26]
Operating temperature range	-52° C to +60°C	-40°C to +60°C	-40°C to +50°C	-40°C to +125°C
Accuracy	±0.3	±0.4	±0.2	±2.5
Power Consumption	3mA	4 mA	25mA	10mA max.
Cost	$2,239.00	$575.00 each	$2,445	$51.66

Observation: WXT520 compact weather station, Met Station One (MSO) weather station, All-In-One (AIO) Weather Sensor are used with respect to temperature, humidity and wind speed but XFAM-115KPASR sensor is only used with respect to wind speed. It is observed that Met Station One (MSO) weather station is the best soil sensor with respect to cost, accuracy. In addition, this sensor has a unique feature of authenticating weather data collected from the various sources.

6. Conclusion

In this paper, we have made a comparison between different soil and environment sensors used in agriculture based on their different features like power consumption, accuracy, cost under different conditions like temperature, moisture, humidity, salinity, conductivity, wind speed. In future, we will consider plant sensors which are also used in agriculture. Some other parameters/conditions like water level, wind direction, atmospheric pressure, rainfall, solar radiation will be taken for future consideration for comparison between sensors. Our future scope is to develop a real-time chat based solution provider like IBM Watson for agriculture with low cost and low power consumption. The farmers will be benefited and GDP will be improved in agriculture in a country like India after the successful implementation of this system.

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