Issues and Challenges in Precision Agriculture

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Abstract: --Modern agriculture requires continuous monitoring of the field using sensors. The recent advancements in the sensor technology make it feasible to analyze various agricultural parameters such as soil moisture, pH level, air humidity, and so on. Wireless sensor network provides a way to collect such agricultural data which can be further transmitted to the farmers. The farmers can take appropriate action to manage the quality of crop. The quality of agricultural data depends on two main factors: type of sensor and deployment strategy of the chosen sensors. In this work, we therefore first discuss the challenges associated to selection of suitable sensors based on power consumption, contact, and direction of sensing. Later, we elaborate the deployments strategies that can adopt to form the wireless sensor network.

Keywords: **--Agricultural field, mobile sink, sensors.**

Introduction

The emerging trends of technical advancement have influenced the area of agriculture which is technically termed as precision agriculture [1], [2]. In precision agriculture sensors are deployed in the agricultural field for monitoring the events of the field. It involves monitoring of different parameters for determining the properties of the agricultural field [1], [3]. The parameters which are monitored inside the field are soil moisture level, temperature, humidity, wind speed, etc. These parameters not only helps in determining the current state of the agricultural field but the prolong collection of such data leads to prediction of the future events and trends. The future event may be rainfall or high temperature which may adversely affect the crop inside the field [4]–[6]. The main objective of precision agriculture is to generate alarm signals and send to the farmer any ill-happening. This allows reduction of the labor for preventing these events from occurring. The sensors are deployed inside the agriculture field to sense the value of the parameters discussed above [7]–[10]. The collected data is then sending to some sink node near the field. The sink will preprocess the data and send it to the Cloud [11], [12]. The values of sensors are analyzed at the Cloud and the course of action for farmer is generated. On the other hand, farmer could also monitor his agricultural land from a distinct location. In precision agriculture the sensors play a vital role, so their deployment pattern and type will affect the quality of service [11]–[13]. Different sensors have different sampling rate and require different amount of power. Each sensor is made for sensing different parameter so they are not compatible with surrounding of the other sensors. The soil moisture sensor will work only when it is dipped inside the soil whereas temperature sensor will sense above the soil. There is no effect of water on rainfall sensor but wind speed sensor must be protected from the water. The deployment of sensors also plays a vital role in determining the service quality achieved by the precision agriculture system [8], [14], [15]. The deployment of the sensors are of three type i.e., triangle, square, and hexagon. The efficiency of the triangle based sensors deployment is high but it requires highest number of sensors amongst all the deployment strategies available. The hexagonal deployment requires least number of sensors but is less efficient. Depending upon the availability of the sensors and level of efficiency the farmer could choose any of the above discussed deployment strategy. Fig. 1 illustrates the deployment of the sensors for monitoring the soil moisture, humidity, temperature of the plants in the garden of CSE department at IIT (BHU) Varanasi.

Fig. 1: Deployment of sensors in garden of CSE department IIT (BHU) Varanasi.

This paper addresses: various issues and challenges in precision agriculture. The main objective is to determine the effect of sensor type and deployment strategies on the precision agriculture. The next Section II will describe type of the sensors and their characteristics. Section III gives a brief detail of the deployment strategies of the WSN used in the precision agriculture. Section IV presents the pros and cons of precision agriculture. Finally the paper is concluding with Section V.

Type of Sensors

The three major categories of the sensors are discussed in this section based upon the power consumption, contact, and direction. These different types of sensors decide the efficiency of the overall precision agriculture system. The taxonomy of the sensors is described in the Table I.

Based on power consumption:

Based upon the power consumption the sensors can be classified as active and passive sensor [16]–[18]. The active sensors require external power for their operation whereas the passive sensor does not require any additional power for their operation. The sensors like carbon microphone, thermistors are active sensors and thermocouples, magnetic microphone, and photodiode are passive sensors.

Table I: Type of Sensors.

Based on power consumption	Based on contact	Based on direction
Active sensor	Contact sensor	Directional sensor
Passive sensor	Non-contact sensor	Omni-directional sensor

Based on contact:

The sensors can be classified as contact sensor or non-contact sensors depending upon the fact that the sensors are in contact with the some object or not. In case of soil moisture sensor the sensor is in direct contact with the soil for sensing moisture of the soil. The temperature sensor on the other hand detects the environmental temperature without any direct contact.

Based on direction of sensing:

Depending upon the direction of sensing the sensors can be classified as the directional or Omni-directional sensors. The Omni-directional sensors can sense in 360 degree but consume more power [19] whereas the directional sensors can sense in specified direction [20]. In Fig. 2 there is an illustration of directional and Omni-directional sensors.

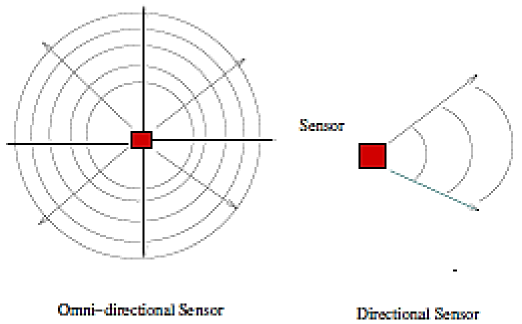

Fig. 2: Directional and Omni-directional sensors.

In precision agriculture type of sensors plays a vital role for determining the quality of service required by the farmer.

Type of Deployment

The sensor deployment can be broadly classified into three categories i.e., triangular, square and hexagonal. In case of triangular deployment the sensors are deployed on three corners of the triangle. Part (a) of Fig. 3 shows the triangular deployment of the sensors. In this deployment maximum sensors are deployed and hence it achieves highest coverage. The major drawback of this deployment strategy is high power consumption as number of sensors is high. In case of square deployment the sensors are deployed at four corners of the square block whereas the in case of hexagon the sensors are deployed at all six corners of the hexagonal. The sensors in the hexagon are spatially separated and hence in hexagonal deployment we require less number of sensors [9]. The power consumption in hexagonal deployment is low but its connectivity is lowest in all three deployments. Part (b) and part (c) of Fig. 1 illustrates square and hexagonal deployment pattern.

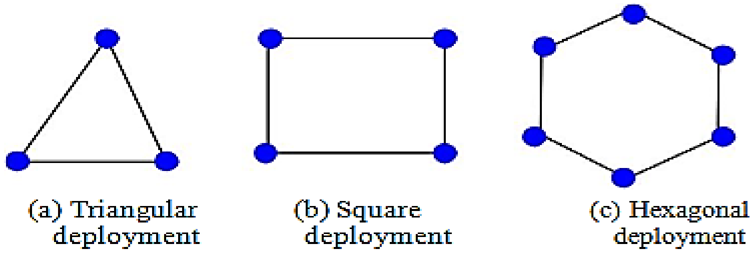

Fig. 3: Deployment of sensors (a) triangular pattern, (b) square pattern, and (c) hexagonal pattern.

Pros and Cons of Precision Agriculture

Precision agriculture is an important source for real-time data collection and information processing, enabling better agricultural decisions. This also provides a subsequent reduction in manual labor of farmers for monitoring the agriculture. All these advantages make the precision agriculture a promising technique. However, the initial installation cost and continuous availability of internet restricts the development of this technique. In this paper, we are reducing the initial installation cost by using raspberry pi in place of laptop or system. The data in raspberry pi is store and communicated to the farmer's smart phone.

Conclusion

The paper first presents the effect of type of sensors on the precision agriculture depending upon the direction, operating power and contact. Next, we present the description of the effect of deployment strategy on agricultural monitoring and also discuss the pros and cons of precision agriculture system. We also suggest mechanism for improving the development of the precision agriculture in practical scenario. This proposed approach is beneficial for farmers and will lead to reduction in labor and distant monitoring of agricultural field for a longer run.

Acknowledgements

This work is supported by Science and Engineering Re-search Board (SERB) file number ECR/2016/000406/ES, project entitled as Development of an Energy-efficient Wireless Sensor Network for Precision Agriculture, and scheme Early Career Research Award.

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