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Survey On Wireless Sensor network in Precision farming

Mrs. Leena Rohan Mehta*, Dr. Kavita Joshi**

**(Department of Electronics and Telecommunication Engineering, Cusrow Wadia Institute of technology, Pune, India -46)*

*** (Department of Electronics and Telecommunication Engineering, G. H. Raisoni College of Engineering and Management, Pune, India)*

ABSTRACT

Recently, Wireless sensor network is gaining immense popularity in agricultural field. This paper surveys various applications of wireless sensor network in smart farming. Precision farming specifically aims towards the development of agriculture by concentrating on the issues like irrigation management, soil moisture measurement, pest detection and overall crop production. It also focus on farm yield improvement. This can be achieved with the help of Wireless sensor network systems. In this sensors are deployed above or beneath the soil, data is collected from the nodes. The collected data is then analysed and action is taken accordingly with the help of microcontroller based systems. Some of the issues associated are also addressed for future development.

***Keywords*:** Wireless Sensor network, Precision Farming, Agriculture, Network Architecture

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I. INTRODUCTION

As the population is increasing day by day, food demands are also increasing. This gives importance to the smart agriculture and farming applications. The introduction of technology in the field of agriculture gave rise to the concept of precision agriculture. PA (precision agriculture) provides means of observing, assessing and controlling agriculture practices. PA covers large area from horticulture to crop production. It takes care of Smart ways to track irrigation, soil, pesticides, flowers and fruit yielding etc. Broadly we can say that it concerns pre-production as well as post-production aspects of agricultural enterprises. Most importantly, in PA, farmers need to know exact and timely details about crop status. These details about certain parameters, obtained by measurements both from the ground and in the air, constitute input data to specialized systems of process management in the PA. Some relevant examples might include irrigation control, pesticide dosage, pest control, etc [5].

Conventionally, monitoring of farms was a difficult and tedious job as it was done remotely and manually. So it was really very inconvenient for the staff working in farms to collect the real time information. The data was carried using cables which resulted in high investment. In order to solve the problem WSN is being used by many in literature. In WSN used in agriculture sensors are located on several locations of a farm to sense the environmental features and then the sensed information is forwarded to the base station through a wireless sensor network (WSN). Following are some of the advantages and disadvantages of WSN.

Advantages

a. Fixed infrastructures are not required for network setup.
b. Typically non accessible places like sea, mountains, rural areas or deep forests can also be connected via WSN.
c. It supports flexibility. Hence extra workstation or node can also be added at any time. It can accommodate new devices easily.
d. Excessive wiring is avoided and hence infrastructure cost reduces.
e. The entire sensor network can be accessed by the centralised monitor.

Disadvantages

a. It is not much secure as hackers can enter the access point easily.
b. The speed of operation is slower as compared to wired communication networks.
c. Configuration of the nodes and the network is bit complex as compared to wired networks.
d. It can get affected by the surroundings very easily. Hence issues with walls, microwaves, signal attenuation due to longer distances etc. exists.
e. If the number of nodes in the network increases, the cost of the system increases.

Precision agriculture (PA) is a modern farming management concept in which computer technologies are employed to monitor, control and optimize agricultural production processes. In PA applications, the data to be sensed is critical. To improve the quality of the production, some environmental values should be sensed and controlled frequently. These operations can be easily supported by WSNs [15].

II. CHALLENGES OF WSN IN PRECISION FARMING

The applications of WSN in PA cover a large set of scenarios and applications. They can be classified into 5 groups as follows [6].

i. Networks of scalar: In this temperature, humidity etc. can be measured. Sensors allow data acquisition for control of greenhouses in order to optimize consumption of resources like water, energy etc.

ii. Wireless multimedia Sensor networks: Detection of certain types of pests, diseases animal tracking, land monitoring etc can be carried out in this. WMSN needs large sensor node capabilities, bandwidth, memory and energy. Also wireless links are more prone to breakage of connections as compared to wired connections.

iii. Tag based systems like RFID or NFC: The history of the produced goods can be monitored and stored on smart tags. Food and agricultural animal traceability impact on early detection of health problems and control of infectious outbreaks. The logistic of any agriculture exploitation can be deeply impacted by the use of RFID technology [6].

iv. Mobility of nodes and disruption of connectivity: In some applications nodes are mobile and remotely connected to servers. Cellular networks are beneficial in these cases however the limitations associated with it are also applicable. Few of the important limitations affecting WSN are limitations in power consumption, connection cost etc.

v. Smart phone based applications: With the help of smart phone farmer can easily keep contact with WSN deployed in his field. But network coverage will be an important issue to be addressed in remote and rural areas majorly in developing countries like India.

III. SYSTEM ARCHITECTURES FOR AGRICULTURAL APPLICATIONS

There has been vast research going on in the field of precision farming. Researchers have suggested use of WSN in applications line animal tracking, pest control, diseases detection, spraying pesticides using drones in air, crop production, plantation, water/ temperature/humidity measurement etc. The main system design of any Wireless sensor network involves sensor node, sink node, transmission networks and monitoring terminals. The broad level of system architecture is as shown in fig. 1.

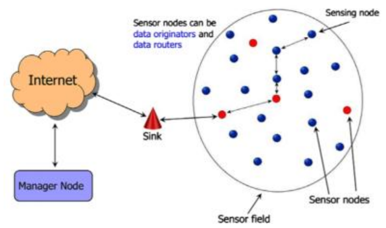

Fig 1. : WSN communication network[8]

In any of the environment monitoring system, sensor nodes are distributed along the farm land. Sensor nodes are responsible for collecting temperature, humidity and other parameter, the collected data is transmitted to sink nodes by multi-hop. Sink nodes which are the core of nodes have more powerful functions of collecting data and storing data ,computing and data integration in a certain than common nodes ; in addition ,wireless sensor network can connect with transmission network and client terminal by sink nodes. The collected data is sent to client terminal through GPS, Internet or any other radio transmission or directly sent to client terminal by cable, and then terminal client analyses data to make a decision [15].

According to Tamoghna Ojha et al. [10] there are two major variants of WSN used for agricultural applications. They are Terrestrial Wireless Sensor Networks (TWSN) and Wireless Underground Sensor Networks (WUSN).

A. *Terrestrial Wireless Sensor Networks (TWSN)*

In TWSN the nodes are deployed above the ground surface. For miniaturization and cost effective sensor manufacturing MEMS technology is used nowadays. The nodes collects the required data and forms the network among themselves. That means they work in collaboration and the a constructive decision is conveyed to the main sensor node.

B. *Wireless underground sensor networks (WUSN)*

In this sensors are planted inside soil. This is useful for lower frequency application environment as higher frequencies face attenuation in this case. Thus communication radius is limited and large number of nodes are needed to cover the farm. But at times these underground sensor motes can be vulnerable for farming.

Table 1 shows the comparison between TWSN and WUSN

Table 1: Comparison between TWSN and WUSN [10]

Sr. No.	Parameter	TWSN	WUSN
1	Deployment	Over the surface of the ground	Under the soil
2	Depth	Anywhere over the ground	0-30cm (topsoil) >30cm (subsoil)
3	Communication range	100m approx.	0.1-10m approx.
4	Frequency of communication	868/915 MHz, 2.4GHz	433MHz, 8-300KHz
5	Size of antenna	Smaller	Larger
6	Power consumption	Lower	Higher
7	Cost	Lower	higher

IV. NETWORK ARCHITECTURE FOR PA SYSTEM

The architecture is classified in various categories as shown in fig. 2.[10]

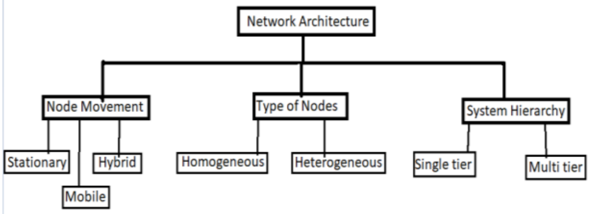

Fig.2: Classification of network architecture [10]

Based on the node movement the WSN architectures are categorized in three main groups namely Stationary, Mobile and hybrid.

i. Stationary: In this sensor nodes are deployed at a fixed positions. They do not change their positions. These are majorly used in irrigation management systems, fertilizer controlling systems etc.

ii. Mobile: In this sensor nodes change their positions with time. E.g. ubiquitous farming operations

iii. Hybrid: In this node are both fixed and mobile. E.g. applications involving fixed sensors deployed on ground and mobile farming equipment

Based on types of sensors the Network architectures are classified as homogeneous and heterogeneous networks.

i. Homogeneous Network: All devices equipped with sensors are of same potential. E.g. agricultural data collection application on the use of pesticides and changing quantity of soil nutrients

i. Heterogeneous Network: In this type of architecture, various types of sensor nodes, and devices are present. These devices vary in terms of computation power, memory, sensing capability, and transceiver units. E.g. irrigation management application

Based on System hierarchy the network architectures are classified into single tier and multi tier networks.

i. Single tier network/Single clustered architecture: In this type of architecture, the on-field devices and sensor nodes directly communicate their data to a sink node placed near the application area.

ii. Multi tier architecture: There are multiple clusters in the architectures. In lowermost clusters the sensors deployed in the farm are present. Thereafter multiple levels of clusters are present to reach towards the gateway. Typically it comprises of heterogeneous nodes.

V. DIFFERENT CATEGORIES OF AGRICULTURAL APPLICATIONS

In this section, various categories of applications important for precision agriculture are presented based on the survey. Also challenges in deployment of WSN in Indian agriculture are also explained.

i. *Irrigation management*: Mahta Moghaddam et. al. suggests smart wireless sensor web technology for optimal measurements of surface-to-depth profiles of soil moisture using in-situ sensors. It aims to sample three dimensional soil moisture fields as a function of time. The system proves that the sensors need not to take data continuously rather they can take it sparsely. The measurement schedule is based on prior statistics of soil moisture evolution, rainfall, and the antecedent data from the sensors[11]. Joaquín Gutiérrez et. al. developed an automated irrigation system using WSN and GPRS which will optimize the use of water for crops. In this distributed approach is suggested. Soil moisture and temperature sensors are placed near roots and gateway are enabled to handle the information received by sensors. Then it is send to the web application. An algorithm was developed with threshold values of temperature and soil moisture that was programmed into a microcontroller-based gateway to control water quantity [12]. The system is proved to be useful and cost effective in water scarcity facing areas.

ii. *Precision farming*: In precision farming the data received from the sensors is analysed and suitable farming conditions are determined to increase the crop production. Dan Popescu et. al. suggested Advanced UAV–WSN System for Intelligent Monitoring in Precision Agriculture. They proposed hierarchical structure based on the collaboration between unmanned aerial vehicles (UAVs) and federated wireless sensor networks (WSNs) for crop monitoring in precision agriculture [4]. Fig. 3 shows the proposed system concept.

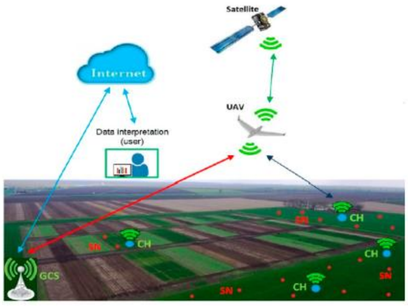

Fig 3: UAV WSN IoT system for precision farming solutions concept [4]

The UAV is fixed wing type and it enable large area coverage with low energy consumption. The Base station collects the primary data received by the field sensors and periodically transmits to the UAV depending on its synchronization. It follows the planned trajectory. Then the data is processed in cloud once UAV uploads the data on internet. Rekha P. et. al suggested a system for providing suggestions about monitoring crop. The system provides the data such as irrigation timings, optimum usage of fertilizers, weather forecasts etc. An android application has been designed for making it user friendly for farmers. App delivers messages in local languages. The sensing subsystem collects the data regarding soil moisture, temperature and pH of the soil. Wasp mote is used and GPRS and WiFi are used for connectivity purposes[16].

iii. ***Pest detection and management***: There are many systems for pest detection and control are available in literature. Many are found to based on acoustic sensing technology. Swarnalatha Srinivas et. al. suggests the methodology to protect from RPW larvae in coconut palm trees [14]. The fundamental frequency of the acoustic activity generated by the RPW larvae also contains environmental noise which is captured by the wireless sensors (nodes) fixed to the palms and transmitted to the server through access points covering number of palms arranged in the form of hexagon for processing using MATLAB tools [13]. In the technique developed by Chandan Kumar Sahu et. al. optical sensors(camera) captures the leaf of the crop and analyses the colour of leaf and detects the infected part of the leaf. The camera is used for capturing the image of crops and sends that image to a processor which processes the image and detects the disease of crops. The camera is fitted with a drone which randomly moves surrounding the agricultural field and takes images.

VI. ISSUES ASSOCIATED IN EXISTING SYSTEMS

i. ***Cost effectiveness***: Currently WSN precision farming systems deployed in developing countries like India need to import majority of the devices from foreign countries. It increases the cost of the system. Hence development of the in house devices and the research for the same can be helpful to reduce the overall cost.

ii. ***Selection of Network based on geographical area:*** Many a times actual scenario for sensor network deployment is much different than the simulation environment. Thus deployment of sensors over the surface or under the soil becomes challenge. It also affects the overall throughput of the network. Therefore selection of the network is important. Typically for flat farms single tier networks can be deployed but it may not be the case for hilly areas or mountain farming. For stepwise farming deployment of sensors is practically difficult.

iii. ***Energy scavenging:*** Generally farms are located in remote areas where electricity is major concern. Thus practical replacement for electricity as source of power need to be found out. Renewable energy sources like solar power, wind energy, RF energy harvesting are few solutions for this. Apart from this vibration energy and biomass can also be important replacements for electricity. Systems and algorithms should also consider this energy management issue.

iv. ***Fault tolerance:*** Node failure is main problem associated with WSN. Thus selection of network topology is important. The topology which supports standby nodes needs to be preferred. But this increases the cost of the system. Apart from this maintenance of accuracy of data, hardware maintenance, calibration etc. are also some of the issues associated with fault tolerance.

v. ***Real time parameter consideration:*** Currently very few researchers have considered real time parameters like changing climates in their system designs. But to implement the WSN in actual precision farming it is very important to consider the parameters like changing weather conditions, changing crop conditions, type of crop, soil type etc.

vi. ***User friendly interface:*** Practical implementation and usage of systems suggested for precision farming is being used by farmers. Most of them are non technical people. Hence user friendly graphic interface should be provided. It needs to be simple. Also training of handling the network in case of minor hardware problems should be given to them. Overall robust and cost effective architectures are needed.

VII. CONCLUSION

WSN plays an important role in addressing the global issue of food scarcity if used in correct ways. In this literature survey paper, different architectures available for precision farming are stated at a length. Also different systems suggested by many researchers for irrigation management, pest detection methods, unmanned aerial vehicle integrated with WSN systems etc. are discussed. Based on detail study of this literature, different issues associated with current applications are discussed.

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