[NC-Rase 18]
DOI: 10.5281/zenodo.1485394

ISSN 2348 – 8034
Impact Factor- 5.070

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

APPLICATION OF WIRELESS SENSOR NETWORKS IN AGRICULTURE: A REVIEW

Prof. S. R. Deshmukh[*1], Prof. P. P. Chavhan[2], Prof. M. M. Patil[3] & Prof. P. V. Thakare[4]
[*1]Department of Computer Science & Engg. MGI-COET, Shegaon, India
[2]Department of Electronics & Telecomm. MGI-COET, Shegaon, India
[3]Department of Electronics & Telecomm. MGI-COET, Shegaon, India
[4]Department of Computer Science & Engg. MGI-COET, Shegaon, India

ABSTRACT

In recent years, wireless sensor networks (WSNs) have received a lot of attention in various research areas. The useful applications of WSN begin by collecting, storing and sharing the detected data. WSN has been used for many applications such as area surveillance, health care monitoring, environmental / land detection, industrial monitoring, agriculture etc. Wireless Sensor Networks (WSNs) consists of different nodes which process and communicate the information collected from different sensors. The wireless sensor nodes send the data wirelessly to a central server, which collects the data, stores it and allows it to be analyzed and displayed as needed. This paper gives review about the need of wireless sensors in Agriculture, WSN technology existing system frameworks in agriculture domain.

Keywords: *wireless Sensor Network. WSN node, Sensors and actuator network*

I. INTRODUCTION

Today, agriculture requires increased food production to meet the needs of vast global population. To achieve this goal, new technologies and solutions are applied in this field to provide an optimal alternative to the collection and processing of information to improve productivity. In addition, alarming climate change and water scarcity require new and improved methods for modern agricultural fields. The advent of wireless sensor networks (WSN) has led to a new direction of research in the field of agriculture and agriculture. Recently, WSNs are a network of battery-powered sensors interconnected via wireless support and are typically deployed to serve a specific application. Crop monitoring to detect environmental conditions and disease detection plays an important role in the success of the crop. The manual collection of data leads to variations from the incorrect measurement taken in the field. This can lead to complications in controlling any important factor. Visual analysis of experts is the main practical approach. We must therefore look for a precise, fast, automatic and less expensive method for the continuous monitoring of the agricultural field. The wireless sensor network can reduce the effort and time required to monitor an agricultural environment. Monitoring fields grown with WSN is a set of network applications that provide tremendous benefits to farmers and society as a whole.

Sensors are used to collect information about physical conditions and environmental attributes while the actuators are used to react on feedback to have control of situations. The field of agriculture poses several requirements that follows:

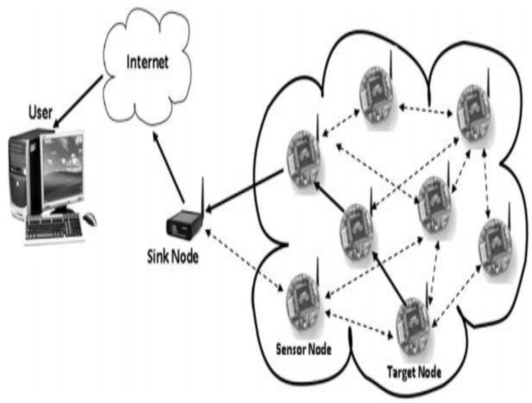
a. Collection of weather, crop and soil information
b. Monitoring distributed land
c. Multiple crops on a single plot
d. Different needs in fertilizer and water for different pieces of uneven land
e. Varied crop requirements for different weather and soil types

In addition, wireless sensors and actuators are needed to collect the necessary information and react on different situations. Decision support requires dealing with information rather than raw sensor data.

ISSN 2348 – 8034
Impact Factor- 5.070

II. WIRELESS SENSOR NETWOK

The use of sensors is becoming possible in almost all areas of life due to technological advances and downsizing. Sensor is a device that can measure physical attributes and convert them into signals suitable for the observer. The Wireless Sensor Network (WSN) consists of several components called "nodes". Nodes are smart devices used to collect application-oriented data requirements. A sensor network performs three basic functions: (i) detection (ii) communication and (iii) calculation using hardware, software and algorithms. Nodes play several roles. The distributed nodes that collect the information are called the source node, while the node that collects information from all the source nodes is called the receiving node and sometimes the gateway node. The receiving node could have a relatively high computing power. A source node also functions as a routing node because of the need for multi-hop routing.



Fig(1): Wireless Sensor Network Architecture

The wireless sensor and actuator network (WSAN) is a variant of the WSN that has an additional type of component, namely an actuator. The inclusion of the actuator increases WSN's ability from monitoring to control.

1. Communication Technologies:

Wireless communication technologies such as ZigBee, Bluetooth, RF and WiFi are part of several research projects based on sensor networks. These technologies have different capabilities and properties on which they are supplemented. ZigBee wireless technology (IEEE 802.15.4) is preferable to other technologies for developing a wireless sensor network because of its low cost and low power consumption. It was introduced in May 2003 and operates on the industrial, scientific and medical (ISM) band, 2.4 GHz, worldwide. There are 16 ZigBee channels of 5 MHz each in a 2.4 GHz band.

Table 1: comparison of different WSN communication technologies

Parameters	ZigBee [3]	Bluetooth [4]	RF[5]	WiFi[6]
Frequency band	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz
Range	30 m–1.6 km	30–300 ft	1500m	100–150 ft
Data rate	250 kbps	1 Mbps		11–54 Mbps
Power consumption	Low	Medium	Low	High
Cost	Low	Low	Low	High
Modulation/pr	DSSS,	FHSS	DSSS/F	DSSS/CC

 ISSN 2348 – 8034
Impact Factor- 5.070

otocol	CSMA/CA		HSS	K, OFDM
Security	128 bit	64 or 128 bit		128 bit

2. Wireless sensor node architecture

The wireless sensor node is a base unit of the wireless sensor network. It comprises 4 basic modules including the sensor module, the communication module, the processing / calculation module and the power module. External memory is optional and may be necessary if data storage is needed for local decision making. Its design requires many considerations such as energy saving, scalability, size, enclosure, etc. The sensor / actuator module provides interfaces to transducers and actuators. The selection of the sensor node is made taking into account the main requirements of the scope, the problem and the distribution model. The processor/ microcontroller, the memory, the working frequency band, the available compatible sensors, the transmission range and the size are some of the main attributes of a sensor node that make it preferable to others. ATmega128L is the most popular microcontroller because of its low power consumption, standby modes, flash memory, byte-oriented storage and compatibility with almost all Tiny OS code. The field of agriculture generates some specific requirements because of which the sensor nodes are also specially designed, while preserving the robustness, housing, support of alternative battery sources, etc. e.g. Lofar node and SPWAS [1-2].

The architecture implemented by deepika et. al. [5] involves integration of sensor network and high definition camera in the field to effectively connect farmers, field and experts instead of farmers or experts directly accessing the field. Sensors are used to provide current status of an environmental condition. The affected leafs are observed by image processing algorithm. The image processing technique has many meaningful applications for detecting the various kinds of diseases such as detect edges of diseased leaf, find shape of affected area, calculate the diseased ratio, separate the layers of target image, and determine the colour of affected area. Long range RF and Zigbee modules are adopted for wireless transmissions. Sensors and cameras are continuously monitoring the crops condition at some delay time. FPGA is used as a controller.

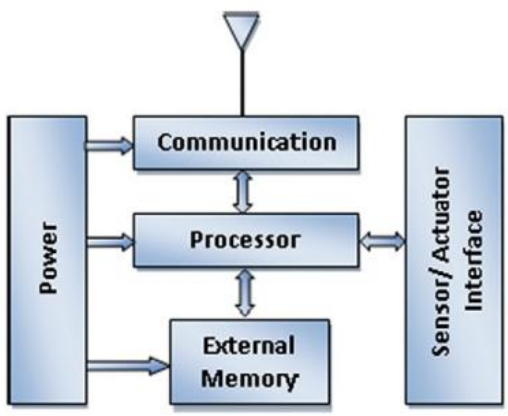


Fig (2): Architecture of WSN node

3. WSN applications in agriculture

The use of sensors, actuators and their network in the field of agriculture is at an advanced stage. Agricultural services such as irrigation, fertilization, pesticide application, animal and pasture monitoring are reviewed in this section. Horticulture is also taken into account because of its importance.

3.1 Irrigation

Irrigation is defined as the application of water in agricultural land and considered as one of the most important constituents of agriculture. The scarcity of water in many areas gives rise to the need for good water use; it should only be provided where it is needed and in sufficient quantity. Different irrigation methods are used, such as drip irrigation, sprinkler irrigation, etc. to deal with the problem of water wastage inherent in traditional methods such as flood irrigation, furrow irrigation, etc.

Damas et al. [7] have developed and tested a remote controlled automatic irrigation system for irrigated areas in Spain. The region was divided into seven subregions. Each sub-region was monitored and controlled by a control sector. The seven control sectors were connected to each other and to the central controller via a WLAN. The results showed significant water conservation, that is, up to 30-60%.Evans and Bergman [8] have worked on the control of precision irrigation of self-propelled, linear displacement and center pivot irrigation systems. Wireless sensors were used in the system to facilitate irrigation planning using remote sensing data and meteorological data. Tapankumar et al. [9] designed and developed a computerized drip irrigation control system to acquire data remotely. They also presented the advantages of storing sensor data for statistical analysis to determine the irrigation needs of different crops.

Yunseop Kim et al. [10] developed a sensor-based irrigation system. Moisture and soil temperature, weather information and sprinkler position were controlled remotely using Bluetooth and GPS technology. The concept behind the development of the project was tomaximize productivity while saving water. Kim and Evans [11] have developed real-time wireless on-site detection and control software for site-specific sprinkler irrigation. They integrated a site-specific irrigation controller with internal feedback and supported real-time decision-making and monitoring of irrigation operations via Bluetooth wireless radio communication.

3.2 Fertilization

Fertilizers are used to increase soil fertility that directly affects plant growth and the quality of food. Several fertilization methods are used such as broadcast, manual spreading and spraying. Optimum fertilizer supply at the required location is a difficult task that requires detection capabilities. The researchers presented different solutions for proper fertilization.

Cugati et al. [25] built an automated fertilizer applicator with input, decision support and output modules using GPS technology, real-time sensors and Bluetooth technology. The input module is used to provide GPS and sensor data values to the Decision Support System (DSS) which calculates the optimal amount and distribution of the fertilizer based on a data acquisition. sensor in real time via Bluetooth communication modules. DSS calculations were used to regulate the rate of fertilizer application.D. Ehlert et al. [26] used their own mechanical sensor (pendulum meter) for site-specific fertilization. A pendulum meter was mounted at the front of the tractor to measure the density of the crop. The sensor was used in combination with a fertilizer spreader, a modified CAN-bus onboard computer and a task calculator to estimate the application of nitrogen in the field. J. He et al. [27] developed and integrated an optimal fertilizer decision support system using wireless LAN sensors using the IEEE 802.11 protocol (WiFi) and a GPS analysis server. Sensors were used to acquire real-time data on humidity, conductivity, temperature, pH, air temperature, humidity, CO2 concentration, lighting, etc. A GIS analysis server was used to interpolate data from small experimental plots for large plots to exploit data reduction for energy conservation.

3.3 Pest control

Agricultural pest management strategies and product research have long been dominated for better pest control. The focus has always been on the development of new and effective products to replace old toxic and ineffective products rather than application strategies. Pest management could be more sustainable when farming practices become more compatible with ecological systems. Sensor networks have also been used to solve fungi and pest problems.

Aline Baggio [1] has developed a project to control Phytophthora disease caused by potato cultivation. The sensors were used to detect humidity and temperature. Following these two facts helped them reduce the disease. Plant diseases often occur in crop plots that require variable rate fungicides and uniform application throughout the field. K.H. Dammer [2] proposed the use of a CROP meter-controlled variable rate field sprayer. Using CROP-meter (real-time sensor for measuring crop biomass density), information on the spatial distribution of leaf area of plants to be sprayed with pesticides can be obtained. The sensor information is used by their algorithm developed to control the dosage of fungicides to be sprayed by the sprayer.

3.4 Animal and pastures monitoring

Butler et al. [13] developed a mobile virtual fence algorithm to control the herd of cows. A smart collar consisting of a GPS receiver, a PDA, a WiFi flash card for WLAN and a loudspeaker audio amplifier is used for each cow in the herd. The position of the animal is verified using the GPS compared to the virtual fence. When approaching a virtual fence, a sound stimulus is generated to move the animals away from the perimeter of the fence. Large-scale cattle surveillance has many requirements and challenges. Radenkovic and B. Wietrzyk [16] presented a distributed peer-to-peer architecture based on a mobile wireless ad hoc sensor network for livestock surveillance nationwide. The core of their research is to propose new data storage and routing systems based on DHT tables (Distributed Hash Tables) that can reduce the major problem of disconnections between nodes. Livestock farming is closely linked to the field of agriculture. Green pastures are used by livestock for grazing. Tim Wark and his other team members [17] at CSIRO ICT Center, Australia, have created an ubiquitous, sensor-based, self-configurable solution for analyzing animal behavior and control as well as assessment pastures. The growth of the grass was analyzed using photographic sensors so that the animals could be moved to green pastures. Their job was mainly to design robust equipment that can be used outdoors to model the behavior of animals and herds. They used a specially designed sensor to monitor animal behavior, such as sleeping, grazing, mulling, etc. In their opinion, this type of behavioral analysis combined with their movement behavior could be used for cow-calf relationships as well as trends in herd behavior. Cattle surveillance is an important task, but it raises several problems, such as radioelectric attenuation caused by the body of the animal, mobility, etc.

III. CONCLUSION

Agriculture is a context rich domain in which the potential of using WSN and WSAN (Wireless Sensor Actuator Network) is very high. A review of several solutions and efforts has been presented in this paper towards agriculture domain. The Wireless Sensor Network architecture is helpful for farmers in enhancing the productivity and increasing the net margin.

REFERENCES

1. *A. Baggio, Wireless sensor networks in precision agriculture, ACM Workshop Real-World Wireless Sensor Networks, Stockholm, Sweden, 2005.*
2. *R. Morais, M.A. Fernandes, S.G. Matos, C. Serdio, P. Ferreira, M. Reis, A ZigBee multipowered wireless acquisition device for remote sensing applications in precision viticulture, Computers and Electronics in Agriculture 62 (2) (2008) 94–106*
3. *K. Nirmal Kumar, R. Prapakaran, "ZigBee Wireless Sensor Network Technology Study for Paddy Crop Field Monitoring", International Conference on VLSI, Communication & Instrumentation, 2011*
4. *Yunseop (James) Kim, Member, IEEE, Robert G. Evans, and William M. Iversen, " Remote Sensing and Control of an Irrigation System Using a Distributed Wireless Sensor Network", IEEE transactions on instrumentation and measurement, vol. 57, no. 7, july 2008.*
5. *Deepika G, Rajapirian P, "Wireless Sensor Network in Precision Agriculture: A Survey",*
6. *Gerard Rudolph Mendez, Mohd Amri Md Yunus and Subhas Chandra Mukhopadhyay, " A WiFi based Smart Wireless Sensor Network for Monitoring an Agricultural Environment", IEEE conference 2012.*
7. *M. Damas, A.M. Prados, F. Gómez, G. Olivares, HidroBus system: fieldbus for integrated management of extensive areas of irrigated land, Microprocessors and Microsystems 25 (3) (2001) 177–184.'*
8. *R. Evans, J. Bergman, Relationships between cropping sequences and irrigation frequency under self-propelled irrigation systems in the Northern Great Plains (NGP), USDA Annual Report. Project, 003–002, 2003.*
9. *T. Basu, M.V.R. Thool, R.C. Thool, A.C. Birajdar, Computer based drip irrigation control system with remote data acquisition system, 4th World Congress of Computers in Agriculture and Natural Resources, USA, 2006.*

10. Y. Kim, R.G. Evans, W.M. Iversen, Remote sensing and control of an irrigation system using a distributed wireless sensor network, IEEE Transactions on Instrumentation and Measurement 57 (7) (2008) 1379–1387.
11. Y. Kim, R.G. Evans, Software design for wireless sensor-based site-specific irrigation, Computers and Electronics in Agriculture 66 (2) (2009) 159–165.
12. K.H. Dammer, Variable rate application of fungicides, Precision Crop Protectionthe Challenge and Use of Heterogeneity, Springer Science and Business Media, 2010, pp. 351–365.
13. Z. Butler, P. Corke, R. Peterson, D. Rus, Virtual fences for controlling cows, The 2004 IEEE International Conference on Robotics and Automation (ICRA), New Orleans, LA, 2004, pp. 4429–4436.
14. M. Radenkovic, B. Wietrzyk, Wireless mobile ad-hoc sensor networks for very large scale cattle monitoring, 6th Int'l Workshop Applications and Services in Wireless Networks (ASWN 06), 2006, pp. 47–58.
15. T. Wark, P. Corke, P. Sikka, L. Klingbeil, Y. Guo, C. Crossman, P. Valencia, D. Swain, G. Bishop-Hurley, Transforming agriculture through pervasive wireless sensor networks, IEEE Pervasive Computing (2007) 50–57.
16. A. Willig, Wireless sensor networks: concept, challenges and approaches, e & I Elektrotechnik und Informationstechnik 123 (6) (2006) 224–231.
17. G. Anastasi, M. Conti, M. Di Francesco, A. Passarella, Energy conservation in wireless sensor networks: a survey, Ad Hoc Networks 7 (3) (2009) 537–568.