Application of wireless sensor networks in precision agriculture: a theoretical reflection

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Abstract

Currently, the use of wireless technologies has provided advancement in the most diverse areas, such as precision agriculture. The use of Wireless Sensor Network in agricultural crops allows monitoring and control of environmental conditions. The communication between the sensors aims to perform the tasks of sensing, collecting, monitoring, transmitting and processing information. The objective of this article is to analyze the application of Wireless Sensor Networks in precision agriculture, as well as its viability, ways of use and related problems. The entire study developed in this article is based on bibliographic research composed of books and electronic articles by renowned authors.

Keywords: wireless networks, sensing, precision agriculture, technology, energy.

1. Introduction

With the constant technological advancement experienced from the second half of the 20th century onwards, the demand for wireless connection technologies has been growing more and more and demanding a greater volume of investments, on the one hand for research and development of new products and, on the other, for the acquisition of devices necessary for practical application. Wireless Sensor Networks (WSN) has a range of possibilities to be used in different areas, such as agriculture, military, environmental, medical, among others.
The application of wireless sensor networks in monitoring agricultural crops can contribute to decision-making, increased productivity and rational use of water. The main advantages of using Wireless Sensor Networks (WSNs) are the absence of cabling and flexibility, which can be used mainly in areas of difficult access, with greater agility in installation - in modification, when applicable -, lower cost and can even reconcile different topologies. On the other hand, the energy restriction consumed by the sensor nodes must be considered, since they are powered by batteries. The objective of this text is to analyze the application of wireless sensor networks in precision agriculture, as well as its viability, ways of use and related problems.

2. Methodology

The entire study developed and materialized in this article is based on analyses from a bibliographical reference composed of books and electronic articles by renowned authors. [1] stresses that the main advantage of bibliographic research lies in the fact that it provides an analytical view of the topic addressed. For [2], "[...] every bibliography already made public in relation to the subject studied [...]" aims "[...] to put the researcher in direct contact with everything that was written, said or filmed about a certain subject".

3. Precision Agriculture

In Brazil, agriculture is one of the most important economic activities. Regardless of the type and size of the farm, as a whole it is an activity that is highly dependent on and influenced by weather conditions. Specifically

in the case of precision agriculture (PA), which is normally practiced in large extensions of land and which intensively uses information technology resources to provide geographic data regarding soil and climate, technical and technological development is also an important element. of great importance. Changes in these elements – climate, technique and technology – can cause major economic, social and environmental impacts.

Precision agriculture (PA) aims to manage agricultural production systems in a macro way, that is, from the application of inputs to the use of mappings in all processes involved in production [3]. It is for this reason that precision agriculture has been using new agricultural instrumentation solutions [4].

Because it demands a considerable volume of investment, precision agriculture is usually used in large tracts of land, which makes the cost-benefit ratio more favorable. According to [4], many farmers are reluctant to make investments involving new technologies and when the return on invested capital occurs in the long term. For this reason, carrying out consistent planning is a fundamental instrument to demonstrate the benefits to be provided by the adoption of a certain technology.

4. Wireless Networks

Wireless technology is already a reality for most people, bringing a series of new features for wireless information exchange. Mobility and quick visualization of information, regardless of location, seek to meet the needs of its users, in a simple and fast way. According to [5]:

In wireless networks, packets are transmitted "over the air", in radio frequency (broadcasting) channels (frequencies in the range of KHZ to GHZ) or infrared (frequency of THz). Wireless networks (based on broadcasting) are a viable alternative where it is difficult, or even impossible, to install metallic or fiber optic cables. Its use is particularly important for communications between portable computers in a mobile local network environment [5].

Wireless networks have part of their invisible structure, where mobile devices have direct contact with a communication centre, known as a base station or Access Point (AP) (Kurose; Ross, 2006). In this sense, for [6], wireless networks are: [...] information technologies involving the use of devices connected to a network or to another device via wireless communication links, such as cellular telephone networks or satellite data transmission, in addition to the following technologies: Infrared (infrared - IR), Bluetooth, Wireless LAN (Wireless Local Area Network) [7].

The main difference between wireless sensor networks (WSNs) is the insertion of sensors in wireless networks. In precision agriculture, these sensors can be multimedia (such as moving image capture) or scalar (such as temperature, pressure, soil moisture and solar radiation level).

5. Wireless Sensor Networks

WSNs (Wireless Sensor Networks) are used to collect, process and disseminate data via wireless communication, about phenomena occurring in a region of interest. These networks are composed of several hardware devices, known as sensor nodes, composed of a microcontroller, battery, data communication unit and sensors (temperature, air and soil humidity, among others). In this way, each sensor node monitors its local environment and forwards the collected and processed data to a central node, called a sink node, whose function is to aggregate all received information and send it to a controller system, commonly known as an Access Point. (PA), which does not happen with wireless ad hoc, networks (Mobile Ad hoc Networks -MANET). According to [8], wireless sensor networks (WSNs) are: [...] deployed to monitor aspects of the physical world. Sensor

nodes are small computers, typically the size of a security token, that have temperature, vibration, and other sensors. Many nodes are placed in the environment to be monitored. They usually have batteries, although they can gather energy from vibrations or the sun. As with RFID, having enough power is a major challenge, and nodes need to carefully communicate with each other to be able to deliver their sensing information to an external collection point. A common strategy is for nodes to self-organize to forward messages to each other [...]. This project is called a multihop network (or multihop network) [8].

For [9], from an organizational point of view, WSNs and MANETs are the same, since the nodes communicate directly with each other through jump sequences with wireless communication. But WSNs have some particular characteristics, such as the use of restricted energy resources, a dynamic network topology and a large number of nodes.

It is worth noting that, for [10], WSNs have different types of configurations, so that each one is planned with its peculiarities, making each WSN application unfeasible for other projects. [11], qualifies the configurations regarding:

- **Composition**: it can be homogeneous or heterogeneous, depending on the composition of the hardware capacity of the sensor nodes.
- **Mobility**: it can be stationary, when all the devices remain in the same place where they were deposited throughout the lifetime of the network; or mobile, when the devices are moved from the place where they were initially deposited.
- **Density**: can be balanced, depending on the network's concentration and distribution of devices per unit area. The network can also be dense (high) or sparse (low), according to the concentration of devices per unit area.
- **Distribution**: the network can be regular, when the network presents a uniform distribution of nodes over the monitored area; or irregular, when the network has a non-uniform distribution of nodes over the monitored area.
- **Size**: being classified as small, the network is composed of a hundred network elements; medium, composed of hundreds to a thousand network elements; or large, when the network is composed of thousands of network elements.

It is also possible to classify wireless sensor networks according to the types employed in the configurations, according to the type of data dissemination, connection, transmission and information flow. Another characteristic refers to the sensing mode, that is, the way to collect the data emitted by the sensor nodes through the sensing of the analyzed environment. According to [11], there are three different ways of collecting:

- **Periodic collection** – data is collected at regular time intervals.
- **Continuous Collection** – Devices on the network collect data continuously.
- **Reactive collection** – data collection occurs when an event happens or when the observer requests to receive data.

As the collection mode is directly linked to energy consumption, which in turn is a bottleneck for WSNs, choosing the ideal mode will have a direct impact on the planning and implementation of the necessary infrastructure. It is important to point out that the continuous collection mode presents a higher energy consumption, which in turn compromises the autonomy of the network.

6. Energy consumption

The low power capacity of the sensor nodes, associated with the shorter communication range between them, are relevant issues in the implementation of a WSN. In view of this, [9] explains that:

Central processing at the sensor node level is performed by a processor whose consumption depends on the clock frequency. Typically this power consumption is proportional to the clock frequency. For extend the life of the batteries it is possible to charge them using some energy from the surroundings. As WSNs must perform collaborative tasks, where it is important to detect and estimate the appearance of events (and not only provide communication mechanisms), normally, data are summarized or treated (in clusters) to improve performance in the event detection process [9].

As the energy consumption will depend on the configuration of the sensor nodes, the choice of these devices will be responsible for significantly reducing or increasing the final cost of the project. In the agricultural sector, for example, data collection can mean greater capacity for rural producers to control the productivity of their crops. However, to avoid waste, it is necessary to evaluate and specify the adequate volume of collections. As a tool that can contribute to the design of a network that meets the real needs and without wasting resources, we have simulators. Through the simulation tools it is possible to obtain results of the total energy that will be spent in each sensor node or in the entire network.

7. Conclusion

The analyzes carried out in this article point to a promising scenario regarding the application of wireless sensor networks in precision agriculture. The application of WSNs in agriculture has as main objective to monitor variables that allow the improvement of the activity, improving productivity and reducing operating costs. Each enterprise will demand a WSN that considers its specificities and needs, which implies the design of specific networks for each project.

The consolidated use of different solutions through WSNs makes it possible for the agricultural enterprise to make decisions related to the cultural treatment through the allocation of resources of type and quantity adequate to the real needs (seeds, fertilizers, pesticides, water, etc.). In this way, the aim is to provide the conditions to increase productivity reduce costs and produce the least impact, making the enterprise more sustainable. It is considered, therefore, that the WSNs refer to the practical application of a technology that will enable productive advances in agriculture.

References

[1] Vergara, S. C. Research projects and reports in administration. 3rd ed. Rio de Janeiro: Atlas, 2000.
[2] Lakatos, E.M.; Marconi, M. A. Fundamentals of scientific methodology. 4. ed. São Paulo: Atlas, 2001.
[3] Embrapa Instrumentation. Precision agriculture: a new look. São Paulo: Cubo, 2011.
[4] Oliveira, R. P. Precision agriculture: information technology in support of classical agronomic knowledge. Technological and Culture Magazine, n. 15, 2009, p. 63-71.
[5] Soares, L. F; G.; Lemos, G.; Colcher, S. Computer networks: from LANs MANs and WANs to ATM networks. 2nd ed. Rio de Janeiro: Campus, 1995.
[6] Kurose, J.F.; Ross, K. W. Computer networks and the internet: a topdown approach. 3rd ed. São Paulo: Pearson, 2006.
[7] Saccol, M. Z. Reinhard, N. Mobile, wireless and ubiquitous information technologies: definitions, state-of-the-art and research opportunities. Journal of Contemporary Administration, vol. 11, no.4. Curitiba, 2007. Available at: <http://www.scielo.br/scielo.php?pid=S141565552007000400009&script=sci_arttext>Accessedon: 27. nov. 2016.
[8] Tanenbaum, A.S, Wetherall, D. Computer networks. 5. ed. São Paulo: Pearson, 2011.

[9] Tavares, J. M. S. Development, simulation and validation of MAC and routing protocols for wireless sensor networks. Master's Dissertation in Electromechanical Engineering – University of Beira Interior. Covilhã, August 2009.

[10] Verona, A. B. Simulation and analysis of wireless sensor networks applied to viticulture. 2010. 93 f. Master's Dissertation in Computer Science – State University of Maringá.

[11] Ruiz, L. B. Manna: architecture for managing wireless sensor networks. Doctoral thesis – Federal University of Minas Gerais, 2003.