Status Paper

A study on IoT-based sensors for precision agriculture

R MADHUMITHA, S PRIYADHARSHINI, K TAMIL SELVAN and V ANANDHI

Department of Physical Sciences and Information Technology
Tamil Nadu Agricultural University Coimbatore 641003 Tamil Nadu, India
Email for correspondence: anandhivenugopal@gmail.com

 Received: 09.02.2020/Accepted: 25.02.2020

ABSTRACT

Internet of things (IoT) is a network in which all physical objects are connected to the internet through network devices or routers and exchange data. IoT allows objects to be controlled remotely across existing network infrastructure. It plays a major role in precision agriculture. Using the sensors we can monitor a specific crop and provide the inputs based on their needs. Sensors in fields measure the moisture content and temperature of the soil and surrounding air. Satellites and robotic drones provide farmers with real-time images of individual plants. Information from those images can be processed and integrated with sensor and other data to yield guidance for immediate and future decisions. Precision agriculture is also called site-specific crop management. The goal of precision agriculture is to ensure profitability, sustainability and protection of the environment. This study provides useful information about the IoT sensors and precision agriculture and how it will be useful to farmers to increase their production.

Keywords: IoT sensors; precision agriculture; network

INTRODUCTION

Internet of things (IoT) is a network in which all physical objects are connected to the internet through network devices or routers and exchange data. IoT allows objects to be controlled remotely across existing network infrastructure. It is a very good and intelligent technique which reduces human effort as well as easy access to physical devices. This technique also has autonomous control feature by which any device can control without any human interaction. 'Things' in the IoT sense is the mixture of hardware, software, data and services. 'Things' can refer to a wide variety of devices such as DNA analysis devices for environmental monitoring, electric clamps in coastal waters, Arduino chips in home automation and many other. These devices gather useful data with the help of various existing technologies and share that data between other devices. Examples include home automation system which uses Wi-Fi or Bluetooth for exchange of data between various devices of home. Precision agriculture (PA) is an approach to farm management that uses information technology (IT) to ensure that the crops and soil receive exactly what they need for optimum health and productivity. The goal of PA is to ensure profitability, sustainability and protection of the environment. PA is also known as satellite agriculture as-needed farming and site-specific crop management (SSCM). Sensors in fields measure the moisture content and temperature of the soil and surrounding air. Satellites and robotic drones provide farmers with real-time images of individual plants. Information from these images can be processed and integrated with sensor and other data to yield guidance for immediate and future decisions such as precisely what fields to water and when or where to plant a particular crop. In IoT-based smart farming a system is built for monitoring the crop field with the help of sensors (light, humidity, temperature, soil, moisture etc) and automating the irrigation system. The farmers can monitor the field conditions from anywhere. IoT-based smart farming is highly efficient when compared with the conventional approach. Technology has changed over time and agricultural drones are a very good example of this. Today agriculture is one of the major industries to incorporate drones. Drones are being used in agriculture in order to enhance various agricultural practices. The ways ground-based and aerial-based drones being used in agriculture are crop health assessment, irrigation, crop monitoring, crop spraying, planting, soil and field analysis.

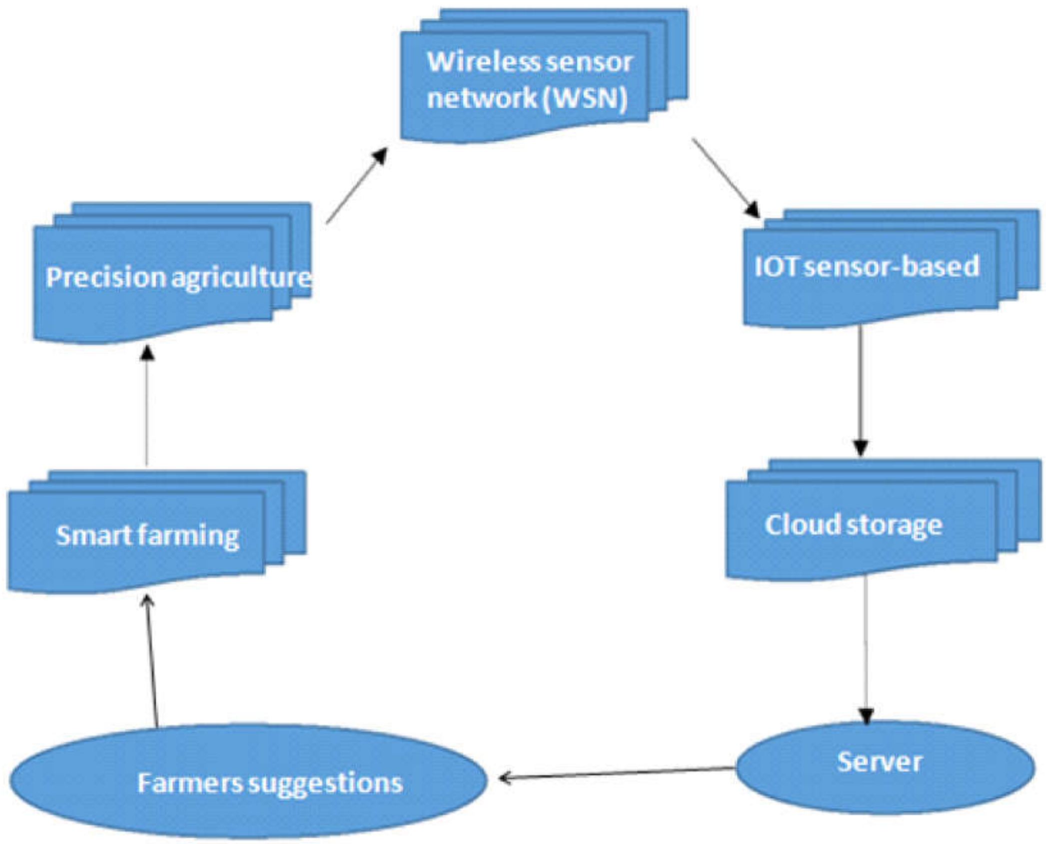
Precision agriculture

Among the proliferation of strategies in the 1970s to improve food production in developing countries has been an emphasis on interdisciplinary teams in the identification, generation and transfer to farmers of appropriate technology (Rhoades and Booth 1982). The very small size of fields allowed farmers to vary treatments manually. However with the enlargement of fields and intensive mechanization it has become increasingly more difficult to take account of within-field variability without a revolutionary development in technologies (Stafford 2000). In the past few years new trends have emerged in the agricultural sector. Thanks to developments in the field of wireless sensor networks as well as miniaturization of the sensor boards, precision agriculture started emerging. Precision agriculture concentrates on providing the means for observing, assessing and controlling agricultural practices. It covers a wide range of agricultural concerns from daily herd management through horticulture to field crop production (Zhang et al 2002). It concerns as well pre- and post-production aspects of agricultural enterprises (Mahalik 2007). PA is conceptualized by a system approach to reorganize the total system of agriculture towards a low-input, high-efficiency sustainable agriculture. This new approach mainly benefits from the emergence and convergence of several technologies including the global positioning system (GPS), geographic information system (GIS), miniaturized computer components, automatic control, in-field and remote sensing, mobile computing, advanced information processing and telecommunications. In simple precision agriculture can be defined as the art and science of using advanced technology to enhance crop production. Wireless sensor network is a major technology that drives the development of precision agriculture. One of the most important sensor for PA field measurement is soil moisture sensor. Soil moisture is the water that is held in the spaces between soil particles. Soil moisture is the key parameter to determine when to irrigate and amount of water to supply. Precision irrigation involves the accurate and precise application of water to meet the specific requirements of individual plants or crops and minimize adverse environmental impact. It is also estimated that 40 per cent of the water used for agriculture in developing countries is lost either by evaporation, spills or absorption by the deeper layers of the soil beyond the reach of plants' roots. Commonly accepted definition of precision irrigation is sustainable management of water resources which involves application of water to the crop at the right time, in right amount, at right place and in the right manner thereby helping to manage the field variability of water in turn increasing the crop productivity and water use efficiency along with reduction in energy cost on irrigation. It is suggested that water savings of around 25 per cent are possible through improvements in application efficiency obtained by spatially varied irrigation applications.

IoT sensors

The IoT is an intelligent network which connects all things to the internet for the purpose of exchanging information and communicating through the information sensing devices in accordance with agreed protocols. The term 'internet of things' was first coined by Kevin Ashton in 1999 in the context of supply chain management. The internet of things (IoT) is regarded as a technology and economic wave in the global information industry after the internet. It is an extension and expansion of internet-based network which expands the communication from human and human to human and things or things and things. In the IoT paradigm many objects surrounding us will be connected into networks in one form or another. It is an evolution of the current internet into network of interconnected objects that not only harvests information from the environment (sensing) and interacts with the physical world (control) but also uses existing internet standards to provide services for information transfer (Gubbi et al 2013). The integration of embedded devices into the internet introduces several new challenges since many of the existing internet technologies and protocols were not designed for this class of devices. These embedded devices are typically designed for low cost and power consumption and thus have very limited power, memory and processing resources and are often disabled for long times (sleep periods) to save energy. The networks formed by these embedded devices also have different characteristics than those typical in today's internet. These constrained networks have different traffic patterns, high packet loss, low throughput, frequent topology changes and small useful payload sizes.

In the past few years several innovations were developed to enable the extension of internet technologies to constrained devices moving away from proprietary architectures and protocols. Most of these efforts focused on the networking layer: IPv6 over low-



Framework

power wireless personal area networks (RFC4919), transmission of IPv6 packetsover IEEE 802.15.4 networks (RFC 4944), IETF routing over low-power and lossy networks or the ZigBee adoptionof internet protocol version 6(IPv6). These new standards enable the realization of an internet of things where end-to-end IP-based network connectivity with tiny objects such as sensors and actuators becomes possible (Ishaq et al 2013).

Methods used

Remote and proximal sensing technologies have been introduced to improve spatial resolution. Remote sensing relies on acquiring images via optical and radiometric sensors installed on an aerial platform or a satellite whereas proximal sensing systems are ground-based (mounted on a vehicle or carried by hand) and linked to a GNSS receiver. The advantage of remote sensing is that images of the entire field can be captured in one shot whereas proximal soil sensors have to be moved across the landscape to create high density measurements that can be mapped. There is an enormous diversity of remote sensing data. The ground resolution, number and width of spectral bands and timing of data collection differ among different service providers. Although remote sensing is useful for evaluating crop conditions, it provides a poor representation of the root zone environment because the data represent the reflectance of the surface material which might be bare topsoil, plant material or a mixture of both. Proximal soil sensing allows for a more direct detection of soil attributes than remote sensing. Three types of sensors are commercially available: electrical or electromagnetic sensors that measure electrical resistivity/conductivity or capacitance; optical sensors that obtain visible and near-rared (Vis-NIR) spectra from within the soil and electrochemical sensors that use ion-selective membranes to detect the activity of ions such as hydrogen, potassium or nitrate. Electrical and electromagnetic sensors measure electrical resistivity/ conductivity, capacitance or inductance affected by the composition of tested soil. Optical and radiometric sensors use electromagnetic waves to detect the level of energy absorbed/reflected by soil particles. Mechanical sensors measure forces resulting from a tool engaged with the soil. Acoustic sensors quantify the sound produced by a tool interacting with the soil. Pneumatic sensors assess the ability to inject air into the soil. Electrochemical sensors use ion-selective membranes that produce a voltage output in response to the activity of selected ions.

Cloud storage

Cloud computing is a model for enabling ubiquitous, convenient and on-demand network access to a shared pool of configurable computing resources (eg networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics, three service models and four deployment models. Cloud computing platform dynamically provisions, configures and reconfigures the servers as and when needed by end users (Alamri et al 2013). There is a need for a powerful and scalable high-performance computing and massive storage infrastructure for real-time processing and storing of the WSN data as well as analysis (online and offline) of the processed information under context using inherently complex models to extract events of interest. In this scenario cloud computing is becoming a promising technology to provide a flexible stack of massive computing, storage and software services in a scalable and virtualized manner at low cost.

Expert system

In artificial intelligence an expert system is a computer system that emulates the decision making ability of a human expert. Expert systems are designed to solve complex problems by reasoning through knowledge represented mainly as if-then rules rather than through conventional procedural code.

CONCLUSION

One of the important processes in agriculture is irrigation. Improper irrigation will result in wastage of water. Wireless sensor network (WSN) and wireless moisture sensor network (WMSN) are components of IoT. Proper irrigation system could be achieved by using WSN technology. Monitoring and control applications have been tremendously improved by using WSN technology. It enables efficient communication with many sensors. IoT allows objects to be controlled remotely across existing network infrastructure. Thus IoT-based sensors play a major role in precision agriculture.

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