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The Internet of Things at the service of tomorrow's agriculture

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Abstract

Smart agriculture is an approach that helps those managing agricultural systems deal with technological changes in an efficient manner, aiming to provide the agriculture industry with the infrastructure to leverage advanced technologies - including big data, the cloud and the Internet of Things (IoT) - to track, monitor, automate and analyze operations.
Thanks to new technologies and precisely the Internet of Things, the agricultural sector will have a radical change to improve efficiency, productivity, global market and reduce human intervention, time and costs. Smart agriculture and IoT-based agriculture are laying the foundation for a "third green revolution," which refers to the combined application of information and communication technologies. This paper focuses on role of IoT in agriculture and presents some devices such as precision equipment, IoT sensors and actuators, geo-positioning systems, unmanned aerial vehicles (UAVs) and robots that leads to smart agriculture.

Keywords: Internet of things, Agriculture, Smart agriculture, Sensors,

1. Introduction

The evolution of technology now allows for more suitable agricultural and housing spaces. Internet of Things (IoT) technology has revolutionized all areas of common life by simplifying it. IoT refers to a network of objects that

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make a self-configuring network. The development of devices based on intelligent agriculture, IoT revolutionizes day by day the agricultural production strengthening it but also making it profitable and reducing waste. The purpose of this article is to help farmers to obtain real data (temperature, soil moisture, the amount of light from the soil environment) for effective monitoring of the environment, which will help to achieve smart farming and increase the overall yield and quality of products.
Smart agriculture also known as, precision agriculture is managed by software and monitored by sensors [10], is becoming increasingly important due to a combination of global population growth, growing demand for higher crop yields, the need to use natural resources efficiently, and the increasing use and need for climate-smart agriculture.
This paper explains the IoT technology used for agriculture. The paper specifically focuses on the sensor technology used for precision farming and agricultural activities. In this paper, the uses and applications of various sensors that are useful in the agricultural process. Their products are commercially available. How these sensors are implemented in agricultural fields. What is the IoT based smart agricultural chain architecture. How this will benefit farmers, consumers and the economy will also be discussed.
Section 1 introduces the agriculture environment in conjunction with the Internet of Things. Section 2 defines some technology principles for agriculture. Section 3 explains the architecture of the IoT-based smart agriculture chain. Section 4 presents the different types of agricultural sensors available and commercialized, and their benefits. Section 5 explains how to enhance data to come out with smart data, with the benefits of using IoT.

2. Some technology principles for smart agriculture

Precision agriculture: it is based on the use of new technologies, such as on-board electronics, satellite imagery and information technology. The location of equipment in the field, including GPS-type satellite positioning systems, increases the level of detail of the information collected. This, in turn, allows for finer intervention by different tools on the plots or on the animals (individualized animal feed, adjustment of fertilizer doses taking into account intra-plot variations via Atfarm, Agro rendement, Greenseeker, etc.). Innovations concerning dairy cows have always been pioneering because the indicator of milk production was daily, unlike meat production. The development of milking tools has continued to improve the accuracy of the information collected, with today's sensors (chips) on board the animals [1].

Digital agriculture: stemming from the previous one, it relies more precisely on the use of electronic tools, from the smart phone to the use of social networks and connected tools to optimize technical itineraries and enhance agricultural production. Digitization consists in recording data on an electronic medium [2].

Smart farming: similar to the previous concept, it is based on the use of data collected at different levels to optimize a decision chain. It emphasizes the notion of intelligence brought to the basic data to extract models that allow for an increase in added value (which may include a reduction in costs). The French concept of connected agriculture seems to correspond best to this [3].

Big Data: giant database on which the development of connected agriculture is based. It is made up of the continuous integration of different information collected throughout the production process, including the environment (climatic, environmental, societal and economic data, etc.). A large potential for development of this Big Data is also based on the IoT, the Internet of Things. If more and more objects in our environment are becoming connected (refrigerators, thermostats, etc.), the same is true of agriculture, where each tool or piece of equipment in the production process is being equipped with a host of connectable sensors, including in the livestock sector. This multitude of data cannot be processed by human intelligence alone, hence the use of algorithms to classify and prioritize it, and extract the essence of it to improve processes [4].

Blockchain: a specific use of Big Data that consists in recording and making public the entire manufacturing process of a product. Particularly applied to agriculture, it should allow to ensure a perfect traceability of consumer goods and financial transactions related to these steps [5].

Drones, robots, satellite maps ...: the above definitions apply to concepts. These are powered by technical components (plant, cow, tractor, smartphone, computer...). Among these components, connected agriculture is particularly fond of new technologies, each of which can provide a type of information or response to the optimization enabled by the interconnection. Their definitions would be too vast to be included in this article [6].

3. IoT-based smart agricultural chain architecture

The Internet of Things is not a single technology. On the contrary, it is the result of the articulation of many bricks, standards and technologies within a whole [11]. We generally distinguish four links in the IoT chain as shown in Figure 1 below:

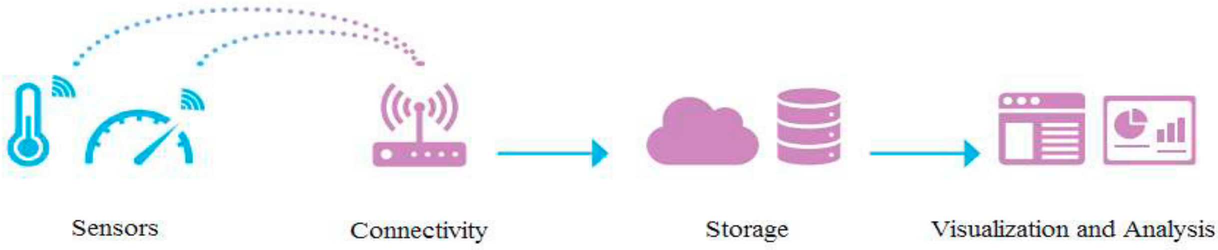

Fig. 1. Link of the IoT chain for Agriculture.

Sensors: from ambient temperature to electricity consumption, from GPS coordinates to liquid level measurement, sensors are now able to provide a wide range of data. For almost every physical quantity, it is possible to possible to identify a technical solution capable of to provide an accurate measurement, in real time.

This equipment is therefore primarily linked to a specific need, but they also include a communication a communication module, most often radio, to enable data to be sent to business applications.

Connectivity: this is what will allow data to be routed from the sensors to the software solution that will use them. Until recently, in addition to until recently, in addition to wired technologies, mobile technology (built on operated networks) was networks) was almost the only technical option available, which available, which had a significant impact on the autonomy of battery-powered systems and the recurring on the recurring cost of the solutions. The new technologies (LPWAN) now allow a sensor to operate several sensor to operate for several years on batteries, making years on batteries, making installation easier, and to transmit to transmit several kilometers away. They also allow for a smaller size of sensors and savings on sensors as well as savings on communication subscriptions.

In addition to sensors in the field, the implementation of connected objects also requires high-speed (3G/4G and soon 5G) and low-speed (LoRa, SigFox, NB-IoT) coverage to transmit data to computer storage servers (Cloud).

It must be admitted that the coverage of these communication networks is often insufficient in rural areas. This limits their deployment of IoT in the field.

Storage: Once collected by the communication network, the data can be stored online or on a provider's infrastructure. At this stage, the data is raw and has not been subject to any specific processing.

Visualization and business analysis: This part includes the intelligence of the solution implemented. It is a matter of extracting, from raw data and thanks to algorithms, intelligible information that can be used for decision-making: soil moisture rate curve, analysis of production equipment vibrations to trigger predictive maintenance, flood alert by sending SMS...

It is interesting to note that these different bricks are potentially independent from each other. In some cases, it is possible to purchase these elements separately to set up a solution, or to acquire an integrated solution from a supplier. [7]

4. More and more efficient sensors at lower cost

The IoT in agriculture is a real wave. The miniaturization of electronic components, the clear improvement in energy autonomy (more efficient batteries), and above all, the drop in technology costs have led to a considerable increase in the number of sensors such as weather stations in the field or activity monitoring devices on agricultural equipment [9]. Recent work even allows us to envisage the development of sensors that directly measure the physiological state of the plant (sap flow, water status of the crop). [8]

4.1. Sensor for plants and fruit trees

This sensor attaches directly to the plant or fruit to collect various signals such as its growth rate or hydration as shown in Fig. 2. below. Combined with other sensors providing climate elements or soil moisture, this information is analyzed and returned to provide a diagnosis on the state of the plant and recommendations.

Fig. 2. Sensor for plants and fruit trees.

4.2. Sensors for greenhouse or hydroponic crops

This open-source system includes a set of sensors recording numerous data: luminosity, air and soil humidity, water temperature, PH... as shown in Fig. 3. below, which are processed on cloud servers. A remote monitoring and an SMS alert system allow to manage the greenhouse and to decide on possible corrective actions.

Fig. 3. Sensor for greenhouse or hydroponic crops.

4.3. Sensor for agricultural drone

Drones are logically well suited for agricultural surfaces as shown in Fig. 4. below, their usefulness depending on the functionality of the sensors used. Offered by one of the leaders in agricultural drones, Agro-sensor is a multispectral sensor for crop mapping. It can be installed on several types of UAVs.

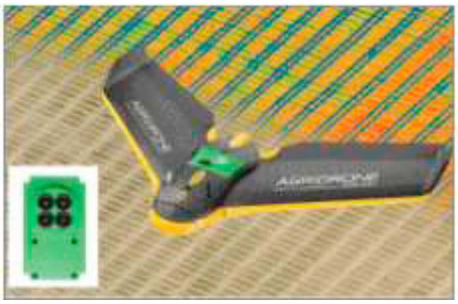

Fig. 4. Sensor for agricultural drone.

4.4. Connected collars

This collar is equipped with sensors that will record information on the health of a cow, whether she is ovulating or pregnant, SMS alerts will inform the farmer in case of changes in the condition of the animal or its behaviour (feeding, rumination ...), as shown in Fig. 5. below.
To locate his herd in real time, this solar powered GPS collar ensures accurate identification. A perimeter not to be exceeded can be defined, with an SMS alert to warn the farmer if it is exceeded.

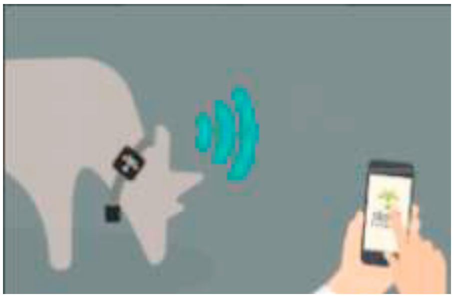

Fig. 5. Sensor for greenhouse or hydroponic crops.

5. Enhance the value of data to make it intelligent and useful information

Once captured and transmitted, the data must be processed to produce intelligent and useful information. This data processing requires an interdisciplinary approach. Mathematicians, computer scientists, agronomists and management science specialists must cooperate to make the most of this data [7].

To facilitate the implementation of these treatments, we talk more and more about the development of AI (Artificial Intelligence). This is a set of theories and techniques implemented in order to create computing machines capable of simulating human intelligence. For example, image recognition applications: after analyzing plant foliage, its algorithms are able to establish a correlation with certain diseases or the presence of weeds.

The main benefits of using IoT to improve agriculture are:

1. Water management can be done in an efficient manner using IoT, without wasting water through sensors.
2. IoT helps to continuous monitor the land so that precautions can be taken at early stage.
3. It increases productivity, reduce manual work, reduce time and makes farming more efficient.
4. Crop monitoring can be easily done to observe the growth of crop.
5. Soil management, such as PH level, water content, etc., can be easily determined so the farmer can sow seeds depending on the soil level.
6. Sensors and RFID chips aids to recognize the diseases occurred in plants and crops. RFID tags send the EPC (information) to the reader and are shared across the internet. The farmer or scientist can access this information from a remote place and take necessary actions, Automatically crops can be protected from coming diseases.
7. Crop sales will be boosted in the world market. The farmer can easily connect to the global market without geographical restrictions.

6. Conclusion

Issues related to the Internet of Things (IoT) are becoming increasingly important and are developing spectacularly in many areas. This development brings many technological innovations, but also generates new problems. The very many IoT devices in use or under development must be classified according to their use, type, Internet connection, location, etc. One of the most important places of use is the agrarian sector and the countryside in general. This is one of the most traditional areas of IoT implementation, but there is still plenty of room for development [12].

With regard to IoT platforms and standards there is a push towards open source software and also open hardware, which, unlike proprietary solutions the compatibility issues of devices and protocols. The deployment of such solutions could expand the possibilities of IoT implementation, as well as reduce implementation costs and establish a stronger foundation for cooperation.

In addition to increasing the quantity and variety of devices used, key areas for IoT development include: development of IoT-specific network technologies [13], security, miniaturization and device integration device integration, reduced power requirements, support for software functionality and usability, use of open source software and open hardware open devices.

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