CONNECTED AGRICULTURE

THE INTERNET OF THINGS

has an impact on all aspects of agriculture

The combination of data from fixed sensors and spatially referenced data is a technical achievement that provides frequent and accurate crop observations.

The rapid development of IT and communication technology has changed the way the selection of agricultural practices is made. We can even safely say that it will transform the way the food industry operates.

Agriculture is facing major challenges. It must maintain its production in terms of quality and quantity, while reducing its impact on the environment. This objective is far from being new, but it now seems achievable through a combination of measures, including using agro-ecology to shift cropping practices, improving varietal genetics to cope with climate change, increasing the use of biocontrol products and plant defence stimulators, and using precision farming tools to refine crop operation management. In any case, observations are crucial to properly monitor crops and react where needed *(see insert)*.

The world of connected objects

Having a wider outlook helps to comprehend the magnitude of the changes that are occurring, including the advent of the Internet of Things, or IoT. Even though this term appeared as early as in 1999, IoT only started being really developed less than a decade ago. It consists in collecting data produced by connected objects or machines, processing them and basing action on the result of their analysis. The leading sectors are currently domotics (house automation), urban planning, the automobile industry, manufacturing and clothing.

But IoT is actually very relevant to the farming industry too. It gives access to the state of crops and their growth environment in real time, more accurately than ever before and in a much simpler way. The aim is to optimise cropping operations. This is known as smart farming.

The advent of IoT did not result from a technological milestone but from the gradual improvement of each component of the information chain, i.e. measurement sensors that have become smaller and cheaper (MEMS[(1)]), with more accessible data (satellite images), wireless communication networks (Sigfox, LoRa, 4/5G…) and information exchange systems (API REST, ETL, No SQL, etc.). To this we need to add a greater data analysis capacity (thanks to IT platforms that are able to cope with the volume and variety of data to be handled, and more advanced processing algorithms) and the incorporation of those improvements into tools such as more precise farm machinery (RTK GPS, direct injection, robots, etc.).

This development has an impact on many players, from network operators and electronic component manufacturers to "cloud[(2)]" solution providers, and of course, agronomists, advisors, etc. Due to its complexity, it is known as a loop, or an ecosystem, rather than a value chain. None of the players can master or control every single link in that loop.

Thanks to the technological revolution we are witnessing, a farmer is not only aware of weather conditions impacting a field, but can access advice through decision support tools.

A technology that needs to be adapted to the agricultural sector

In farming, that ecosystem needs to be further developed and structured. This is mainly due to two types of obstacles, technical and economic.

Technical issues currently concern the availability of sensors able to cope with farming constraints, and the lack of communication systems in rural areas. For example, sensors that measure crop characteristics such as pheromones in the air or nitrates in the soil still need to be developed. Data processing algorithms also need to follow suit, with image, spectrum and time series analysis, georeferenced and timed data fusion, etc. This must in turn lead to the design of forecasting and advisory tools based on this new type of information, including through machine learning[(3)].

Of course, those barriers are research and commercial activity opportunities, provided investors are not put off by the necessary investments. But from a technical point of view, none of those hurdles constitute insurmountable obstacles.

If quality assurance schemes require greater precision, agricultural IoT will become crucial to ensure that the production's quality is maintained at a sufficiently high level.

A significant economic hurdle to overcome

Understanding the economic obstacles is key to understanding why IoT is still fairly underdeveloped in agriculture. Although it is economically important, the agricultural industry is characterised by low margins and long-term return on investment. In addition, the value carried by this new information is still relatively unknown. It is spread out between all the industry's players, from producers to storage operators, traders, processors and consumers, which makes it particularly difficult to quantify. This new technology must therefore be implemented as part of long-term multidisciplinary and multipartner studies *(see insert)*. Until the value and cost effectiveness of those solutions is proven, start-up companies, their backers and other industries will be reluctant to make any significant investments. Yet, those investments are needed to achieve large-scale production and, in turn, to lower the price of the actual systems and spread the cost of data hosting and analysis.

Some factors work in favour of adopting the Internet of Things, including the fact that a large proportion of that loop's components is reusable between applications. For example, the same sensors, communication systems and IT infrastructure, as well as some of the data processing algorithms can be used to study beetroot *cercosporiosis* and wheat *septoria*. Conversely, field data acquisition and the models developed will remain application specific. Who will bear the additional cost of solving both those crucial issues? And how easy is it to alter the scale? The "who gets what" question needs to be answered. This must be done on a case-by-case basis, i.e. for each crop, or even each cropping operation. The economic equation is difficult to resolve at present. If the terms of this equation change (molecule ban or withdrawal, greater encouragement to opt for greener practices, etc.), or if agricultural product prices rise because of quality assurance schemes (production charters that include greater precision in farming practices) or tensions on world markets, the agricultural IoT will become essential to keep producing the amounts and the quality required.

(1) MEMS stands for micro electro-mechanical systems.
(2) Storage area on big data Internet network servers.
(3) The term machine learning refers to a group of IT-based learning methods that help, for example, to automatically recognise objects based on large numbers of observations.

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A connected weather station

The weather station concept is not new, but new dynamics have been created by the advent of the Internet of Things. Cheaper sensors and the standardisation of electronic systems, including the creation of low-bandwidth communication networks, have all contributed to lowering the price of a station. By providing real-time data every 15 minutes, connected weather stations help to make better decisions regarding crop operations and improve work efficiency.

Although different manufacturers provide different types of products (provision of weather data only, or linked to a service platform), they all offer a community mode that gives access to all the information made available by the whole weather network around a farm. This means that farmers could share the cost of the investment.

However, this being a recent technological advance, the lifespan and autonomy of the equipment cannot yet be assessed. In addition, farmers must be made aware of the constraints brought by this type of equipment, particularly concerning its maintenance and positioning, which are paramount to ensure the quality of the measurements.

Field assessment of connected objects in farming

The successful candidate of the research and innovation framework programme Horizon 2020's call for projects devoted to connected objects in agriculture was the European project IOF2020 (Internet of Food and Farm).

Started in January 2017, it brings together over 70 public and private European partners aiming to demonstrate the viability of IoT technologies via 30 use cases in the farming and food industries, and to achieve a large scale implementation of solutions that have been developed and validated by users. The project focusses on five main production and processing sectors: arable crops, fruit, vegetables, meat and milk. In partnership with Orange, Hiphen and Bosch, Arvalis is testing field sensors designed to measure crop development, nitrogen nutrition, water stress, as well as temperature and ambient humidity, in real time. Prototypes (opposite) have been installed in bread wheat fields at the Boigneville Digiferme®, near Paris. This technology is going to improve existing irrigation and nitrogen management support tools. By focussing on modularity and interoperability, those sensors are designed to be rolled out on a larger scale.

See also https://www.iof2020.eu/