A concept note on Internet of Things

Smart field management with the use of sensors and Decision support tools

As geopositionning and sensor technologies progress, cropping systems benefit from new technology that makes it possible to implement precision farming practices to refine input management. At the moment, the most widely known example of such applications is probably the development of boom sections control, guidance bars and steering assistance. At another level, spatial advice based on satellite images (FARMSTAR®, developed in conjunction with Airbus defence and Space) has greatly improved since it was introduced in 2002. It will reach 800,000 ha in 2016 with 15,000 hectares of wheat and oilseed rape newly-covered with UAVs. In 2015, this service was being used on 740,000 ha of wheat and oilseed rape. But its development potential on that market remains great (14 million hectares of arable crops in France). For example, the potential of the French market for in-field nitrogen management DSTs is estimated at 50M€, compared with its current level of 10M€.

Significance of precision crop management from field to silo

With the advent of the Internet of Things (IoT), and the rapid development of technologies due to the evolution of communication networks (mobile telephony, very high speed connections and narrow band, short and long range), to the Cloud, to big data processing (Big Data, Machine Learning) and to a new generation of sensors and machine-to-machine connections, new opportunities are emerging. In an agricultural context, those technologies help capture and transmit geolocalised real time information at low cost. Once gathered, processed and analysed, this data helps to measure the state of the environment and of the plants, and when combined with agro-climatic models, to establish forecasts and give advice in order to better manage technical interventions. Precision crop management has a major significance for future cropping systems. This significance applies to several objectives:

- Enhancing the competitiveness of the production systems through a more efficient way of managing inputs
- Matching production with market expectations in order to meet quantitative and qualitative needs. For example, matching the protein content and safety quality of wheat to expectations using cropping practices and climatic conditions requires a more precise fertilisation and crop protection management system.
- Protecting the environment and preserving biodiversity through the use of increasingly precise techniques that help to avoid excessive use of products and unintentional effects that may be harmful.

The concept of precision farming has often been associated with the aim of capitalising on variations within a field by varying input applications. This remains one of the major objectives of precision farming and still offers possible further progress. However, we also need to consider other ways of capitalising on the data captured. Adding in-field data and/or inter-field data does indeed open up new perspectives, such as the possibility of determining the characteristics of the forthcoming harvest (yield and quality) over a whole region, or of assessing the impact of cropping practices over a given catchment area.

Development opportunities based on complementary skills

Combining the most advanced technology in the field of sensors and of data transmission via a network with available climate-soil-plant models, will foster the development of a precision crop management service at field level. The combination of state-of-the-art technology (soil/plant/air sensors, networks, data platforms, etc.) with information concerning a specific field will provide the farmer with a value-added crop management service.

Such a service means designing a high-performance database management system (Big Data) as well as an information system that will enable an almost instantaneous link between the data-gathering phase and feedback of elaborate advice to the user. This lends itself to the creation of several subgroups of study themes:

- Identification and interpretation of the signal emanating from the field components: soil, plant and climate
- Adaptation of agronomical models based on the spatial management of inputs
- Creation of an interactive information system (top down and bottom up) for data gathering, processing and storing, as well as data circulation.

Like many other research institutes, Arvalis has become involved in API (Application Programming Interface – See API-AGRO® platform) in order to find a way for the various databases and modelling tools to communicate between them. This solution has the merit of ensuring that the various databases and information tools coming from various sources are compatible between them. In addition, it greatly simplifies the issue of data and software ownership: the tools remain the property of the designer, and their use is subject to authorisation which is only granted for a specific task. The user can therefore only access the result or the data he/she needs, without seeing anything else.

More precise and large scale crop management: utilising and combining knowledge and technologies of the future

« Precision crop management has a major significance for future cropping systems. Connected sensors provide highly complementary information to already available data such as satellite imagery **»**

Large-scale experiments have helped to establish the list of key factors of success in delivering crop management which is more effective and has a higher added value.

First of all, it is becoming increasingly obvious that several steps are required between the moment the sensor emits a signal and the time when advice can be delivered to the farmer, from the conversion of the signal into an indicator from which an impartial agronomical diagnosis can be established, to the conversion of the diagnostic indicator into advice.

The value of the information, (level of precision of the advice, as well as possibility of extrapolating to a variety of local situations) is directly dependent on implementing the entire processing chain, which uses the conclusions drawn from the knowledge gathered as well as from the teledetection, ecophysiological, agronomical and decision models that can be utilised in combination with sensors and various support vectors.

ARVALIS has developed a complete model (CHN®), which was successfully tested in many situations and over many years, including in fields cropped by farmers using different practices. This work took around 10 years to complete, and now helps simulate precisely the growth of different species (C, or dry matter produced), the amount of water (H, in the soil, absorbed, evaporated or transpired), and the amount of nitrogen (N, in the soil and in the plants). No other model is currently capable of competing with CHN®, especially considering that a model must be usable and robust enough in a very wide range of situations (availability of input variables, tested parameter setting). Improving the precision of both the input and output variables will contribute to deliver precision advice within a field, based on CHN® model.

All those sensors helped ARVALIS acquire a great level of expertise through the programme led by UMT CAPTE, which was dedicated to developing and assessing sensors for crop characterisation and management purposes. In practice, this meant that three scientists specialising in signal processing and tool development were made available (patent in partnership with INRA for the Kit-piéton® sensor, PHENOMOBILE® in co-ownership with INRA, integration of a drone data processing chain, design and testing of individual sensors in association with manufacturers, etc.).

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Phenomobile®, a field device equipped with sensors (photo ARVALIS)