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Editorial

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Agriculture, and agronomy, is currently being revolutionized by the use of digital technologies. The dissemination of data and digital equipment on farmlands, livestock holdings and in the environment forge the future of farms where agricultural machines are not only interconnected but are also capable of interacting with their human operators. These machine systems are already able to collect, aggregate and process data in order to assist users in their decision-making process, or even go so far as to automate part of the operations. The fields are monitored by remote sensors (satellites or drones), with ground or animal-borne sensors providing a constant stream of data. Farmers are able to make their decisions based not only on local data but also by accessing remote data sources (weather forecasts, simulations, archives and tweets). They then enact their decisions by commanding distant actuators (irrigation systems, milking and feeding robots, etc.). Decisions could also be transmitted to and circulated via remote systems in the form of alerts on social media and/or mobile networks (disease risks, crop development stages, climatic events, etc.). In order to be effective, the information transmitted needs to be relevant so as to favor making the right decision at the right time within an ever-evolving and highly complex environment.

This digital farm, a possible evolution of precision agriculture and of smart farming that are already in use today, raises methodological issues involving complex, heterogeneous, distributed data that is often voluminous and sometimes incomplete or inaccurate. These issues often involve a significant human component, including multiple actors engaging with an evolving environment requiring increasingly autonomous equipment. This set of problems indeed lends itself well to the innovative solutions that would be provided by implementing Artificial Intelligence methods, offering novel services to operators, future consumers and the environment. In order to address these issues, an Inrae/Inria white paper [1] explores various issues involved in understanding, mastering, preparing and supporting the deployment of digital technologies in agriculture, both on farmlands and in those sectors serving farmers, agriculture and the common good.

This special issue of the Revue Ouverte d'Intelligence Artificielle (ROIA) provides an overview of current research addressing the use of artificial intelligence techniques in agriculture. We put out a request for contributions demonstrating the relevance, practical feasibility and thematic scope of Artificial Intelligence on the digital farms of tomorrow. This issue has been divided into two main parts. The first part contains articles dealing with data analysis strategies that use machine-learning methods. The processed data is in the form of images issuing from various sensors. In the second part, we then grouped those articles using knowledge and actor modeling methods in order to better grasp the complex workings of farmlands.

The article by Rémi Régnier et al. offers an original perspective on the results of the ROSE challenge, which is the first international robotics and Artificial Intelligence competition aimed at evaluating the performance of weeding robots in real-world conditions on cultivated fields. This challenge made way for the authors to address the issue of the general characterization of intelligent robotic systems. Their efforts thus lay the groundwork for future methodologies and harmonized protocols for evaluating future agricultural robotics systems.

The next two articles present learning methods based on image analysis in order to evaluate agricultural yields. Following on from those is an article called "Image processing and machine learning towards precision viticulture", which is the fruit of a collaboration from within the European H2020 project "Artificial Intelligence for Digitizing Industry". This article describes the state of the art with respect to various techniques for analyzing images of vines in order to predict their yields. Yield prediction can be carried out at different stages of vine development, although the relevant elements may naturally vary : inflorescences, flowers, clusters or berries. The article provides standard machine learning techniques and deep learning techniques as regards the elements to be detected. The results of these techniques are then compared in terms of the quantity of images, types of images, imaging conditions shooting conditions, grape varieties, as well as the metrics and settings used. The authors conclude that the standard techniques, contrary to the deep learning techniques, require highly complex manual settings. However, deep learning techniques are unfortunately very demanding when it comes to the large quantities of manually labeled data and computing power required, making standard techniques much more affordable. This highlights the need for a benchmark containing large amounts of heterogeneous images in order to effectively compare all these techniques. This overview of the state of the art serves to demonstrate that, over and above the technical aspects of computing, shooting conditions and media vary greatly and indeed have a significant impact on the results.

The third article, by Eliott Jacopin et al., focuses on the automatic detection and counting of plants in cultivated fields by means of aerial images. Such detection methods would allow farmers to better predict the state of the crops and their future yields, and would provide agronomists with a quick and easy way to collect large volumes of experimental data. The method they put forward is derived, on the one hand, from unsupervised learning based on clustering to reveal an initial identification of rows and plants, and, on the other hand, from using a multi-agent system requiring relatively few settings in order to refine this estimation and to isolate each plant properly. Combining learning and MAS resolution is certainly a novel approach, and one that provides highly relevant experimental results.

Artificial intelligence techniques can also prove very useful in terms of crop planning.

In the article by Maqrot et al., entitled "Designing orchard/market garden systems assisted by mathematical programming", the authors offer to solve the issue of planning the growing of five market garden crops (lettuces, tomatoes, onions, melons and carrots) on an agroforestry plot containing apple trees. Firstly, they demonstrate the difficulties associated with choosing the right locations for the trees and the crops on the same plot of land due to the interactions between them. Trees cast shade over the crops, thereby limiting airflow and affecting the thermal and evaporative stress of the crops. The root systems of trees and crops compete for the soil water. The authors designed a mathematical model of these interactions in order to build a decision system for planning the location of crops and trees on the same plot for two consecutive years. Two mathematical models aimed at resolving these crop planning issues are put forward : a quadratic model with binary variables and a linear model with mixed variables. These two models were created using two different optimization software programs : Cplex and LocalSolver. Preliminary solutions were obtained in a reasonable amount of time, despite the large number of variables. These solutions, however, leave room for improvement since, contrary to common practice by farmers, they split the plot into two parcels : a mixed tree-crop zone and a market garden zone.

The two remaining articles concern the use of various Artificial Intelligence tools in order to simulate and analyze complex systems, such as those encountered in agri-environmental applications.

In the article entitled “Simulating the transition from intention to action in agriculture”, R. Martin-Clouaire and J.-P. Rellier present a modeling tool for agricultural production systems that is geared towards action planning. Their work aims to provide a modeling formalism which lends itself to the specificities of such complex systems as agricultural farmlands. It was necessary, in particular, to account for uncertainties over time (climatic and production uncertainties), as well as work organization (personnel and material constraints). For the authors it was thus a case of creating a formalism to define a flexible plan which would be operationally dependent on the actual course of events, thereby taking contingencies into account. Their work, therefore, demonstrates all the complexities associated with the effective organization of farms, as well as the possible contribution of automated reasoning methods (planning and temporal reasoning) with respect to improving their management : increasing efficiency, facilitating the work of farm operators and optimizing the use of resources.

In the article by L. Sadou et al., a model showing the dynamics of accepting innovation is explored. More specifically, the authors endeavor to understand the dynamics involved in getting farmers to accept the installation of interconnected water meters in an agricultural region. To achieve this, they thus use a multi-agent system based on an argumentation framework in order to better understand which points to stress in order to convince the farmers (the agents) to adopt these linked water meters. Their work is thus situated as the crossroads between the fields of argumentation and multi-agent simulation.

We sincerely hope that the research contained herein will go a long way towards demonstrating the impact of Artificial Intelligence on shaping digital agriculture, and that it will also serve to clarify what AI is capable, and incapable, of accomplishing.

Bibliographie

[1] V. Bellon-Maurel, L. Brossard, F. Garcia, N. Mitton, E. Prados & A. Termier, « Livre blanc INRIA / INRAE sur le numérique en Agriculture », in *PFIA 2020 - (Plateforme de l’Intelligence Artificielle) - Journée Agronomie et IA* (Virtual, France), Jun 2020, p. 1-26.