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Special issue on Agri-Food 4.0 and digitalization in agriculture supply chains - New directions, challenges and applications☆

1. Introduction

Agri-Food is a complex industry, which challenges a wide range of processes, operations, and roles world-wide. Moreover, it is largely inefficient with an increasing number of demands and constraints being placed on it, making the need for Agri-Food innovative solutions ever more important. Agri-Food related stakeholders such as manufacturers, producers and retailers, as well as government and policy making departments, are intrinsically linked to globally key challenges in terms of defining and implementing sustainable solutions and, as it happens with all industries, technology plays a key role in the operations and decision-making of the Agri-Food sector.

In fact, in the Agri-Food sector, the agriculture industry has experienced a positive trend in digitalisation initiatives, but introducing it efficiently is the new challenge (Hernandez et al., 2017). Computers are now everywhere in farming related processes, from machineries to all agribusiness decision-making systems, this also includes the use of robots, sensors and cyber-physical systems technologies as a support. Therefore, the Agri-Food sector presents a great potential to radically be enhanced in terms of its intelligence, efficiency, sustainability and performance by using integrated decision support systems jointly with advanced internet-based networks and services, specially by considering the Agri-Food 4.0 digital approach, which implies a factor for agriculture acceleration and support in terms of sustainability, land management, quality of the life and competitiveness (Hernández Jorge et al., 2018).

However, unlike the technical innovation, there are no standards ecosystems in digital world. Digital solutions are ingraining complexity into an already complex environment, which highly impact the business processes required to implement the digital strategies. Hence, the digital back office of Agri-Food will also be a subject of special attention, especially regarding to dematerialisation and bureaucracy processes. An additional challenge in Agri-Food 4.0 will emerge in terms of integrating demographic changes, digital technology, climate change, poverty and unequal distribution of resources in the sector (Zhao et al., 2019b).

Therefore, the Agri-Food sector provides novel and up-to-date use cases for Future Internet1 design, from the physical layer all the way up to the service layer transforming data into first-class entities. While the current Internet secures the communication channel or path between two communication points and sometimes the data with encryption, Future Internet secures the content and provides essential context for security. In this context, the Internet of Things (IoT) and Cyber-Physical Systems (CPS) technologies can play a leading role in the digitalisation of agriculture, allowing effective real-time monitoring, rationalisation of interventions and cost containment. This will lead to make companies more competitive on their global market and to improve the sustainability and management of the territories. This implies that an important role will be played by the Agri-Food 4.0 to support the farming and challenges and requirements through technologies breakthroughs related to smart farming, sensors and traceability; smart logistics, focusing on real-time virtualisation, connectivity and logistics intelligence; and smart food awareness, focusing on transparency of data and knowledge representation.

2. Outline of the special issue

The first paper of this special issue, authored by Mario Lezoche, Jorge Hernandez, Maria del Mar Eva Alemany Diaz, Hervé Panetto and Janusz Kacprzyk, is entitled "**Agri-food 4.0: a survey for the Agriculture Supply Chains of the Future**". This paper is a survey and a vision of the challenges facing the so-called "Agri-Food 4.0″ (Lezoche et al., 2019). The term "Agri-Food 4.0″ is an analogy to the term Ïndustry 4.0″, coming from the concept "agriculture 4.0″. Hence, Industry 4.0, it is about including and integrating the latest developments based on digital technologies as well as the interoperability process across them. In fact, all agricultural machinery incorporates electronic controls and has entered to the digital age, enhancing their current performance. However, the use of the right methods and methodologies for enhancing agriculture supply chains performance is still a challenge, thus the concept of Industry 4.0 has evolved to agriculture 4.0 in order analyse the behaviours and performance in this domain. In this survey, a review of more than hundred papers on new technologies and the new available supply chains methods are analysed and contrasted to understand the future paths of the Agri-Food domain.

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The second paper, authored by Jhonattan Miranda, Pedro Ponce, Arturo Molina, Paul Wright is entitled "**Sensing, smart and sustainable technologies for Agri-Food 4.0**" (Miranda et al., 2019). Currently, the agri-food sector takes advantage of modern machinery, tools and emerging information and communication technologies that consider the Internet of Things capabilities. These implementations have given way to a new era of agri-food production called 'Agri-Food 4.0′, where automation, connectivity, digitalisation, the use of renewable energies and the efficient use of resources are predominant in this sector. In this article, the 'sensing, smart and sustainable (S3)' concept is applied to develop new technologies that can respond to current challenges of agri-food industries, focusing on describing how S3 technologies for the agri-food sector can be developed using a systematic process for new product development.

The third paper, authored by Pedro Mondino and José L. Gonzalez-Andujar, is entitled "**Evaluation of a decision support system for crop protection in apple orchards**" (Mondino and Gonzalez-Andujar, 2019). This paper evaluates a Web Decision Support System (SSD Manzano) for the diagnosis and control of pests in apple orchards, from the practical and educational viewpoints. The adoption of this system allows pesticide applications in the most opportune moments achieving a reduction of pesticide use and its side effects.

The fourth paper, authored by Biljana Mileva Boshkoska, Shaofeng Liu, Guoqing Zhao, Alejandro Fernandez, Susana Gamboa, Mariana del Pino, Pascale Zarate, **Jorge Hernandez**, and Huilan Chen, is entitled "**A Decision support system for evaluation of the knowledge sharing crossing boundaries in agri-food value chains**" (Boshkoska et al., 2019). This work proposes a decision support system (DSS) for evaluation of knowledge sharing crossing boundaries in agri-food value-chain. The proposed DSS is developed through two phases: (i) identification of the most common knowledge boundaries by using machine learning and ontology technologies; (ii) transformation of the obtained ontology into a DSS for the evaluation of existing knowledge boundaries. In particular, the developed DSS helps in identifying, evaluating and providing directions for improvement of the knowledge sharing crossing boundaries in agri-food value-chain.

The fifth paper, authored by Solemane Coulibaly, Bernard Kamsu-Foguem, Dantouma Kamissoko, Daouda Traore, is entitled "**Deep neural networks with transfer learning in millet crop images**" (Coulibaly et al., 2019). Plant or crop diseases are important items in the reduction of quality and quantity in agriculture. Therefore, the detection and diagnosis of these diseases are very necessary. The appropriate classification with small datasets in Deep Learning is a major scientific challenge. Furthermore, it is difficult and expensive to generate labelled data manually according to certain selection criteria. The approaches using transfer learning aims to resolve this problem by recognizing and applying knowledge and abilities learned in previous tasks to novel tasks (in new domains). In this paper, the authors propose an approach using transfer learning with feature extraction to build an identification system of mildew disease in pearl millet. The deep learning facilitates a practically fast and interesting data analysis in precision agriculture. The expected advantage of the proposal is to provide support to stakeholders (researchers and farmers) through the information and knowledge generated by the reasoning process.

The sixth paper, authored by Maria Carmela Annosi, Federica Brunetta, Alberto Monti, Francesco Nat, is entitled "**Is the trend your friend? An analysis of technology 4.0 investment decisions in agricultural SMEs**" (Annosi et al., 2019). Smart Agriculture and 4.0 Technologies have brought several benefits to agricultural small and medium enterprises (SMEs). Nonetheless, the penetration of such digital technologies is still poor and slow. This paper studies the issue and provides some insights on the reasons related to the still limited adoption of 4.0 technologies within agricultural SMEs.

The seventh paper, authored by Guoqing Zhao, Shaofeng Liu, Carmen Lope, Haiyan Lu, Sebastian Elgueta, Huilan Chen, Biljana Mileva Boshkoska, is entitled "**Blockchain technology in agri-food value chain management: A synthesis of applications, challenges and future research directions**" (Zhao et al., 2019a). Agri-food value chain is an area of significant importance because of providing sustainable, affordable, safety and sufficient food, feed, fibre and fuel to consumers, it is critical to ensure these value chains running smoothly and successfully by applying advanced internet technologies. Blockchain technology is a new digital technological approach underpinned by the Industry 4.0 to ensuring data integrity and preventing tampering and single point failure through offering fault-tolerance, immutability, trust, transparency and full traceability of the stored transaction records to all agri-food value chain partners. This paper used systematic literature analysis to review the state-of-the-art blockchain technology including its recent advances, main applications in agri-food value chain and challenges from a holistic perspective.

The eighth paper, authors by Jean-Pierre Belaud, Nancy Prioux, Claire Vialle, and Caroline Sablayrolles, is entitled "**Big data for Agri-Food 4.0: Application to sustainability management for by-products supply chain**" (Belaud et al., 2019). This paper proposes an approach that integrates big data, to improve sustainability management in supply chain design. It aims at valorising agricultural waste by using environmental impacts to assess the various processes and their panels of technologies; The work is applied in the process of bioconversion of lignocellulosic biomass to produce bioenergy, biomolecules and biomaterials.

The last paper, authored by Tuhin Sengupta, Gopalakrishnan Narayanamurthy, Roger Moser, and Pradeep Kumar Hota, is entitled "**Sharing App for Farm Mechanization: Gold Farm's Digitized Access Based Solution for Financially Constrained Farmers**" (Sengupta et al., 2019). Due to its increasing supply-demand gap in India, which is attributed to the increasing population, the rapid urbanization, and the low productivity, farms mechanization should increase the production as well as reduce the used resources. In this paper, the authors propose a digitalized access-based solution that can help in overcoming the financial constraints experienced by the farmers in accessing expensive farm equipment.

The Editors of this special issue of Computers In Industry would like to express their gratitude to the authors for their excellent contributions. We are also very grateful to all reviewers who have dedicated efforts in reviewing these papers, and for their valuable comments and suggestions that significantly improved the overall quality of the contributions. We hope that this special section will serve as a good reference for researchers, scientists, engineers, and academicians in the field of the industry of the future.

Declaration of Competing Interest

The authors, Hervé Panetto, Mario Lezoche, Jorge E. Hernández, Maria Del Mar Eva Alemany Diaz and Janusz Kacprzyk do not have any conflict with interest.

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