Guest Editorial
Circuits and Systems for Smart Agriculture and Healthy Foods

THIS Special Issue of the IEEE JOURNAL ON EMERGING AND SELECTED TOPICS IN CIRCUITS AND SYSTEMS (JETCAS) is dedicated to Circuits and Systems applied to innovative products for the Agriculture and Food value chain.

Nowadays, and in the light of the report recently issued by the United Nations (Intergovernmental Panel on Climate Change – IPCC Report 2021), the benefits that technology provides to a green and sustainable economy are highly appreciated and under intense research and development globally. Circuits and Systems, specifically, which are the base for any system, can bring the needed functionalities and performance for reaching eco-friendly, circular and practical solutions.

Electronics is crucial for interfacing the data sources, extracting the data and processing them, obtaining the needed information along the whole food chain: from the farmer, the professional stakeholders to the consumers and waste management. The impact on scientific research spans from sensors to readout electronics and the related smart systems, which are all helpful in processing the information and transmitting utilizing various efficient paradigms. Last but not least, CAS are creating effective methodologies for collecting and processing the massive amount of complex data, acquired from diverse scenarios and with strong interrelations among them. Therefore, the investigation of novel approaches using machine learning and artificial intelligence algorithms is on the top list today of research and development of circuits and systems for agriculture and food.

All mentioned technologies must reach the desired levels of low power and low cost in order to be valuable and efficient solutions for AgriFood at the global scale, supporting food security and sustainability. The electronic circuits and systems should be ecumenically sustainable all along the food chain to keep the profit margin of the industry and farmers on the one hand and allow reasonable food costs to the customers on the other hand. Therefore, the application of novel technologies has to be economically sustainable, and in many cases, the applications must be autonomous and/or operational for an extended period of time. Hence, systems with the lowest possible power consumption and high reliability should be conceived.

This Special Issue aims to cover a few, but significant, examples of the state of research in Circuits and Systems applied to the AgriFood value chain. It covers several important methods and technologies, highlighting the key approaches beneficial for this research field.

The published papers mainly cover two application categories, the smart systems for precision agriculture and food logistics, and the sensing methodologies for food, including intelligent data processing. The contribution to the research of the selected papers will be detailed in Sections I and II, respectively.

I. SMART SYSTEMS FOR PRECISION AGRICULTURE AND FOOD LOGISTICS

Six of the eight selected papers describe electronic systems covering the most important technological solutions useful for reaching AgriFood value chain targets.

"How to Feed a Growing population" of V. Grimblatt et al. is related to the Internet of Things (IoT) systems, which are one of the most essential solutions nowadays available and that can help AgriFood have a significant step forward to the desired application targets. This paper describes an IoT Approach to Crop Health and Growth towards creating effective devices for respecting the environment. It is well stated in the paper that "… A convenient way to address this issue is to produce efficiently respecting the planet. Non-invasive technology at a low cost is a solution to monitor crop growth and health, helping small to medium farmers to increase their productivity keeping in mind the conservation of the planet. Circuits and Systems offer large range of possibilities. We propose to investigate IoT with medium cost sensors to deliver real time, affordable and precise data processing for agriculture producing an Automated Decision-Making Systems (ADMS)". The paper describes a specific application for monitoring plant growth, but the presented approach can be easily generalized for other types of AgriFood domains.

In "A versatile, stand-alone, in-field sensor node for implementation in Precision Agriculture" by M. Sophocleous et al., the vital role of soil measurement for precision agriculture is well described. The described sensor node is equipped with different sensors, particularly with a potentiostat for electrochemical measurements, devoted to measuring, for example, the pH of the soil. Electrochemical sensors' importance is not confined to the soil, but it is fundamental for measuring Volatile Organic Compounds (VOCs), which are key parameters for understanding plant status. This work is so of interest for many different applications for smart agriculture.

The contribution given by the work presented in "Automated Pest Detection with DNN on the Edge for Precision Agriculture" by A. Albanese et al. is related to the use of Deep Neural Networks (DNN) for image processing, highlighting the effectiveness of the use of intelligent algorithms for extracting information from raw data. Here the detection approach is well known and standard, an embedded camera, but innovation is in the data elaboration methodology. Machine Learning is exploited for ensuring continuous detection of pest infestation inside fruit orchards, with a long lifetime of the battery powering the system, a crucial aspect for obtaining a positive impact in the use of electronic systems for what is named precision or smart agriculture.

A similar methodology is used in "A Low-Cost, Low-Power and Real-Time Image Detector for Grape Leaf Esca Disease Based on a Compressed CNN" by L. Falaschetti. The authors present a solution for early detection of the appearance of a disease (Esca). The prevention of diseases and, in general, dangerous situations for the crops, also related to the environment, is one of the most significant support that electronic technologies can bring. The design of efficient devices and systems that can prevent loss of production yields has an immediate impact on the AgriFood economy.

In "On the Interpretation of Four Point Impedance Spectroscopy of Plant Dehydration Monitoring" by L. Bar-On et al., the innovative and ultra-low cost & power methods based on impedance spectroscopy is presented. The measurement of impedance for understanding plant health is promising, giving the possibility of implementing very low complex electronics and exploiting the immense experience in impedance measurements. Its effectiveness is proven by the paper, where the results of the electrical measurements are compared to those of the standard in agriculture gravimetry methods. The results confirm that the trunk impedance depends on the plant status, similar to the value expressed in the gravimetry system.

The work described in "LoRaWAN ESL for food retail and logistics" of M. Miguez et al. covers the fundamental aspects of network management, in this case, applied to food logistics. As already mentioned, autonomous and so power-efficient devices have to be designed. The paper analyses how IoT can "expand the application horizon", bringing the needed effective solutions. It is specifically described how Electronic Shelf Labels (ESL) can present the price in an innovative and very interesting way to the customer, building a dynamic generation of the price and the product's information. The connection of the ESL to a central server by LoraWAN allows the calculation of the real-time price that depends on marketing and customer satisfaction strategies, applicable with a minimal investment of time and efforts.

II. Smart Sensors and Methodologies for Food Monitoring

Two papers of the Special Issue are focused on innovative sensors and their related systems for food monitoring. Sensors and the way of interpreting the data are key aspects of AgriFood technologies.

"Machine-Learning Based Microwave Sensing: A Case Study for the Food Industry" by M. Ricci et al. presents an innovative detection method based on microwaves, targeting the possibility with existing technologies of remotely sensing the needed parameters with low-cost solutions, improving in the same time test efficiency. This type of contactless methodologies will have by sure an essential impact for future implementations. In this paper, as stated by the authors, microwave sensing is used as an alternative method that, combined with machine learning classifiers, can tackle the deficiencies of existing technologies, not ready to reach the needed accuracy.

For avoiding actual destructive tests on fruits, the paper "Non-destructive Assessment of Kiwifruit Flesh Firmness by a Contactless Waveguide Device and Multivariate Regression Analyses" by C. Berardinelli et al. is an excellent example of how contactless methodology can be effective, joint with an efficient use of intelligent algorithms for extracting the information from raw data.

Acknowledgment

First of all, the Guest Editors would like to extend their gratitude to all the authors who committed their time and efforts in contributing technical excellence and insights to this Special Issue. Without their outstanding contributions, we would not be able to keep the high-quality standards for this JETCAS Special Issue. We also would like to thank the anonymous reviewers for providing valuable comments and suggestions on the submissions. We are grateful to the Editor-in-Chief (EiC), Prof. An-Yeu (Andy) Wu, Associate EiCs, Prof. Herbert Iu and Prof. Wen-Hsiao Peng, as well as the Senior Editorial Board for their continuous guidance, support, and advice. We hope this Special Issue will spark the interest of many related researchers, bring a synthesized source and broad view of recent progress, and facilitate further progress in this crucial research area.

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