POLITECNICO DI TORINO
Repository ISTITUZIONALE

Guest Editorial Circuits and Systems for Smart Agriculture and Healthy Foods

(Article begins on next page)

08 November 2022

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.

DANILO DEMARCHI, *Corresponding Guest Editor*
Department of Electronics and Telecommunications
Politecnico di Torino, Italy
Visiting Professor, Tel Aviv University, Israel
e-mail: danilo.demarchi@polito.it

JULIUS GEORGIOU, *Guest Editor*
Holistic Electronics Research Laboratory
Electrical and Computer Engineering Department
University of Cyprus, Cyprus
e-mail: julio@ucy.ac.cy

VICTOR GRIMBLATT, *Guest Editor*
Synopsys, Santiago, Chile
IMS Laboratory, Université de Bordeaux, France
e-mail: victor.grimblatt@synopsys.com

YOSI SHACHAM-DIAMAND, *Guest Editor*
The Bernard L. Schwartz chair for nano scale information technologies, Department of Electrical Engineering - Physical Electronics and the Department of Material Science and Technology Faculty of Engineering
Tel Aviv University, Israel and
Endowed Chair Professor, Thapar institute for Engineering and Technology (TiET), Patiala, India and director of the TAU/TiET Food Security Center of excellence at TiET
e-mail: yosish@tauex.tau.ac.il

Danilo Demarchi (M'10-SM'13) received Engineering Degree and Ph.D. in electronics engineering from Politecnico di Torino, Italy, in 1991 and 1995, respectively. Full position as Associate Professor at Politecnico di Torino, Department of Electronics and Telecommunications, Turin, Italy. Visiting Professor at Tel Aviv University (2018-2021) and EPFL Lausanne (2019). Visiting Scientist at MIT and Harvard Medical School (2018). Author and co-author of 5 patents and more than 250 international scientific publications. Prof. Demarchi is the leader of the MiNES (Micro&Nano Electronic Systems) Laboratory at Politecnico di Torino, Member of the BioCAS Technical Committee, Associate Editor of IEEE Sensors Journal and the Springer Journal BioNanoScience, Member of IEEE Sensors Council, General Chair of IEEE BioCAS 2017 and founder of the IEEE FoodCAS Workshop (Circuits and Systems for the Food Chain).

Julius Georgiou (M'98-SM'08) received his M.Eng degree in Electrical and Electronic Engineering and Ph.D. degree from Imperial College London in 1998 and 2003 respectively. For two years he worked as Head of Micropower Design in a technology start-up company, Toumaz Technology. In 2004 he joined the Johns Hopkins University as a Postdoctoral Fellow, before becoming a faculty member at the University of Cyprus in 2005, where he is currently an Associate Professor.

Prof. Georgiou is a member of the IEEE Circuits and Systems Society, was the Chair of the IEEE Biomedical and Life Science Circuits and Systems (BioCAS) Technical Committee, as well as a member of the IEEE Circuits and Systems Society Analog Signal Processing Technical Committee. He served as the General Chair of the 2010 IEEE Biomedical Circuits and Systems Conference and was the Action Chair of the EU COST Action ICT-1401 on "Memristors-Devices, Models, Circuits, Systems and Applications - MemoCIS". Prof. Georgiou was an IEEE Circuits and Systems Society Distinguished Lecturer for 2016-2017. He is a recipient of a best paper award at the IEEE ISCAS 2011 International Symposium and at the IEEE BioDevices 2008 Conference. In 2016 he received the 2015 ONE Award from the President of the Republic of Cyprus for his research accomplishments.

Victor Grimblatt has an engineering diploma in microelectronics from Institut Nationale Polytechnique de Grenoble (INPG – France) and an electronic engineering diploma from Universidad Tecnica Federico Santa Maria (Chile). He is doing his PhD on IoT for Smart Agriculture at IMS lab, University of Bordeaux. He is currently R\&D Group Director and General Manager of Synopsys Chile. He has published several papers in IoT, EDA and embedded systems development. From 2006 to 2008, he was member of the "Chilean Offshoring Committee" organized by the Minister of Economy of Chile. In 2010 he was awarded as "Innovator of the Year in Services Export". He is also member of several Technical Program Committees on Circuit Design and Embedded Systems. Since 2012 he is chair of the IEEE Chilean chapter of the CASS. From 2021 he is member of the CAS Board of Governors. He is also the President of the Chilean Electronic and Electrical Industry Association (AIE).

Yosi Shacham-Diamand, D.Sc. EE 1983, M.Sc. EE 1980, and B.Sc. EE (Summa-cum Laude) 1978, all in the Technion-Israel Institute of Technology, Haifa, Israel. Yosi has also been a visiting professor, CNR-IMM, Rome, Italy, Visiting Professor, Waseda University, Tokyo, Japan, a distinguished international chair professor, Feng Chia University, Taichung, Taiwan, and a visiting professor at the Department of Electronics and Telecommunication, The Politecnico di Torino, Torino, Italy. Currently, he is the head of the international electrical engineering school at Tel Aviv University and an endowed chair professor at the Thapar institute for engineering and technology, Patiala, India and the director of the TAU/TIET Food Security center of excellence. His research is in the field of Micro and Nano electronics science and technology; specifically, electroless plating of metals and alloys, interconnect technology for ULSI circuits and flexible electronics, and electrochemical bio sensors the food, medical and agro applications.