

# **2023 IEEE Conference on AgriFood Electronics (CAFE 2023)**

**Torino, Italy  
25-27 September 2023**



**IEEE Catalog Number: CFP23KZ3-POD  
ISBN: 979-8-3503-2712-0**

**Copyright © 2023 by the Institute of Electrical and Electronics Engineers, Inc.  
All Rights Reserved**

*Copyright and Reprint Permissions:* Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limit of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923.

For other copying, reprint or republication permission, write to IEEE Copyrights Manager, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854. All rights reserved.

***\*\*\* This is a print representation of what appears in the IEEE Digital Library. Some format issues inherent in the e-media version may also appear in this print version.***

IEEE Catalog Number:	CFP23KZ3-POD
ISBN (Print-On-Demand):	979-8-3503-2712-0
ISBN (Online):	979-8-3503-2711-3

**Additional Copies of This Publication Are Available From:**

Curran Associates, Inc  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: (845) 758-0400  
Fax: (845) 758-2633  
E-mail: [curran@proceedings.com](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

CURRAN ASSOCIATES INC.  
**proceedings**  
.com

# CAFE 2023 TABLE OF CONTENTS

---

---

## Plant Monitoring and Crop Analysis Innovations

Date: Monday, September 25, 2023  
Time: 10:30 - 12:00  
Room: Room 1  
Chair(s): Umberto Garlando, Politecnico di Torino  
Andrea Boni, University of Parma

### Examination of Plant Physiological Monitoring Alongside In-Vivo Four-Point-Probe Impedance Spectroscopy of Live Tobacco Plants ..... 1

Lee Bar-On, Yarden Zeron, Nier Sade, Adi Avni, Yosi Shacham-Diamand  
*Tel Aviv University, Israel*

### Coffee Crop Detection from UAS Orthomaps with Convolutional Neural Networks ..... 5

Sergio Arriola-Valverde<sup>1</sup>, Santiago López-Rojas<sup>1</sup>, Daniel Ramírez-Valerio<sup>2</sup>, Eduardo Somarriba-Chavez<sup>3</sup>, Renato Rímolo-Donadío<sup>1</sup>

<sup>1</sup>*Instituto Tecnológico de Costa Rica, Costa Rica*; <sup>2</sup>*Instituto del Café de Costa Rica, Costa Rica*;  
<sup>3</sup>*Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica*

### A Genetic NOT Gate in Transgenic Tobacco Based on Estradiol-Induced Translational Repression ..... 10

Aakash Jog, Ron Sverdlov, Adi Avni, Yosi Shacham-Diamand  
*Tel Aviv University, Israel*

### Capacitive Impedance Analysis for Non-Contact Assessment of Fruit Quality and Ripening ..... 15

Fahimeh Masoumi<sup>1</sup>, Andrea Gottardo<sup>2</sup>, Pietro Ibba<sup>1</sup>, Matteo Caffini<sup>2</sup>, Antonio Altana<sup>1</sup>, Paolo Lugli<sup>1</sup>, Luisa Petti<sup>1,2</sup>

<sup>1</sup>*Free University of Bozen-Bolzano, Italy*; <sup>2</sup>*MiCROTEC/BIOMETiC S.r.l, Italy*

### Towards Tomato Plant Iron Stress Monitoring Through Bioimpedance and Circuit Analysis ..... 20

Saleh Hamed, Pietro Ibba, Antonio Altana, Paolo Lugli, Luisa Petti  
*Free University of Bozen-Bolzano, Italy*

### Radish Plant Growth Monitoring Using Multimodal Fusion ..... 25

Shreya Bansal, Malya Singh, Seema Barda, Vikas Kumar, Neeraj Goel, Mukesh Saini  
*Indian Institute of Technology Ropar, India*

# AI-Based Pest Detection and Contaminant Monitoring in Agriculture

Date: Monday, September 25, 2023  
Time: 14:00 - 15:30  
Room: Room 1  
Chair(s): Francois Rivet, University of Bordeaux  
Mohammad Russel, Dalian University of Technology

## Plant Disease Detection: Electronic System Design Empowered with Artificial Intelligence ..... 30

Jiayi Wu<sup>1</sup>, Usman Dar<sup>2</sup>, Mohammad Hossein Anisi<sup>1</sup>, Vahid Abolghasemi<sup>1</sup>, Chris Newenham<sup>2</sup>, Andrey Ivanov<sup>2</sup>

<sup>1</sup>University of Essex, United Kingdom; <sup>2</sup>Wilkin & Sons Limited, United Kingdom

## Parallel Execution of the Viola-Jones Algorithm on MCUs for Low-Cost Automated Pest Detection ..... 35

Manuele Rusci<sup>1</sup>, Luca Bompani<sup>2</sup>, Olmo Baldoni<sup>2</sup>, Carlo Montanari<sup>2</sup>, Davide Brunelli<sup>3</sup>, Luca Benini<sup>2,4</sup>

<sup>1</sup>Katholieke Universiteit Leuven, Belgium; <sup>2</sup>Università di Bologna, Italy; <sup>3</sup>Università degli Studi di Trento, Italy; <sup>4</sup>ETH Zürich, Switzerland

## Enhanced Machine-Learning Flow for Microwave-Sensing Systems to Detect Contaminants in Food ..... 40

Bernardita Štitić<sup>1</sup>, Luca Urbinati<sup>1</sup>, Giuseppe Di Guglielmo<sup>2</sup>, Luca Carloni<sup>3</sup>, Mario R. Casu<sup>1</sup>

<sup>1</sup>Politecnico di Torino, Italy; <sup>2</sup>Fermi National Accelerator Laboratory, United States; <sup>3</sup>Columbia University, United States

## Development of a Deep-Learning Pipeline to Detect and Locate Contaminants of Industrial Products via Non-Invasive Microwave Signals ..... 45

Margherita Musumeci<sup>1</sup>, Juan Sebastian Amaya Cano<sup>1</sup>, Filippo Lazzati<sup>1</sup>, Chiara Martano<sup>1</sup>, Francesco Pappone<sup>1</sup>, Claudio Ramonda<sup>1</sup>, Marco Ricci<sup>2</sup>, Jorge A. Tobon V.<sup>1</sup>, Giovanna Turvani<sup>1</sup>, Mario R. Casu<sup>1</sup>, Marco Mussetta<sup>1</sup>, Francesca Vipiana<sup>1</sup>

<sup>1</sup>Politecnico di Milano, Italy; <sup>2</sup>Wavision Srl, Antares Vision Group, Italy

## Popillia Japonica Newman Detection Through Remote Sensing and AI Computer Vision ..... 50

Davide Brusco, Elena Belcore, Marco Piras

Politecnico di Torino, Italy

## Comparative Study of Camera- and Sensor-Based Traps for Insect Pest Monitoring Applications ..... 55

Athanasios Passias, Karolos-Alexandros Tsakalos, Nick Rigogiannis, Dionisis Voglitsis, Nick Papanikolaou, Maria Michalopoulou, George Broufas, Georgios Ch. Sirakoulis

Democritus University of Thrace, Greece

## Innovations in Livestock Management and Precision Farming

Date: Tuesday, September 26, 2023  
Time: 9:15 - 10:30  
Room: Room 1  
Chair: Alfredo Arnaud, Universidad Católica del Uruguay

### Research Platform to Study Sheep Behavior ..... 60

V. Cabrera<sup>1</sup>, A. Delbuggio<sup>1</sup>, H. Cardoso<sup>1</sup>, D. Fraga<sup>2</sup>, A. Gómez<sup>1</sup>, M. Pedemonte<sup>1</sup>, R. Ungerfeld<sup>1</sup>, J. Oreggioni<sup>1</sup>

<sup>1</sup>Universidad de la República, Uruguay; <sup>2</sup>DVL Group, Uruguay

### A Nonlinear Model Predictive Controller for Trajectory Planning of Skid-Steer Mobile Robots in Agricultural Environments ..... 65

Katherine Aro<sup>1</sup>, Ricardo Urvina<sup>1</sup>, Nestor Deniz<sup>2</sup>, Oswaldo Menendez<sup>3</sup>, Jamshed Iqbal<sup>4</sup>, Alvaro Prado<sup>1</sup>

<sup>1</sup>Universidad Católica del Norte, Chile; <sup>2</sup>Universidad Técnica Federico Santa María, Chile;

<sup>3</sup>Universidad Andrés Bello, Chile; <sup>4</sup>University of Hull, United Kingdom

### Audio-Based Identification of Queen Bee Presence Inside Beehives ..... 70

Luca Barbisan, Giovanna Turvani, Fabrizio Riente

Politecnico di Torino, Italy

### Efficient Monitoring of Livestock Feed Inventories ..... 75

Tim Bell<sup>1</sup>, Roger D. Chamberlain<sup>2</sup>, Chris Edmiston<sup>1</sup>, Addison Elliott<sup>1</sup>, Todd Steinbrueck<sup>1</sup>

<sup>1</sup>BECS Technology, Inc., United States; <sup>2</sup>Washington University in St. Louis, United States

### Smart Chicken Farming; Case Study in North Rift Kenya ..... 80

Allan K. Koech<sup>1</sup>, Fidel Makatia<sup>1</sup>, Valery Chebet<sup>2</sup>

<sup>1</sup>Autodesk, Inc., Kenya; <sup>2</sup>Kenyatta University, Kenya

## Enhancing Food Chain Integrity with Sensing Technologies

Date: Tuesday, September 26, 2023  
Time: 10:45 - 12:00  
Room: Room 1  
Chair(s): Luisa Petti, Free University of Bozen  
Zhongyang Cheng, Auburn University

### High Sensitivity Milk Adulteration Detector Using Fractional Order Colpitts Oscillator ..... 85

Agniv Tapadar, Avishek Adhikary

Indian Institute of Technology Bhilai, India

### Investigation on Wireless Communication for Sensors in IoT Cold Chain ..... 89

Nicola Dilillo, Renato Ferrero, Filippo Gandino, Maurizio Rebaudengo

Politecnico di Torino, Italy

### Digitizing Fresh Food Supply Chains to Reduce Loss and Waste ..... 94

Carlos Esquerre Fernandez<sup>1</sup>, Anastasia Ktenioudaki<sup>1</sup>, Emily Crofton<sup>2</sup>, Cristina Botinestean<sup>2</sup>, Jean-Pierre Emond<sup>3</sup>, Ultan Mc Carthy<sup>1</sup>

<sup>1</sup>South East Technological University, Ireland; <sup>2</sup>Teagasc Food Research Centre, Ireland;

<sup>3</sup>The Illuminate Group, United States

**Edible Electronics for Sustainable Agrifood: Towards the Integration of Edible Rechargeable Batteries with Sensor Networks** ..... 99

Valerio Galli<sup>1,2</sup>, Giulia Coco<sup>1,2</sup>, Valerio F. Annese<sup>1</sup>, Mario Caironi<sup>1</sup>

<sup>1</sup>Istituto Italiano di Tecnologia, Italy; <sup>2</sup>Politecnico di Milano, Italy

**Development of Coffee Classification by Feature Selection and Classifier Optimization Based on an Electronic Nose** ..... 104

Jui-Ching Wu<sup>1</sup>, Ting-I Chou<sup>1</sup>, Shih-Wen Chiu<sup>2</sup>, P.K. Shihabudeen<sup>1</sup>, Po-An Chen<sup>3</sup>, Kea-Tiong Tang<sup>1</sup>

<sup>1</sup>National Tsing Hua University, Taiwan; <sup>2</sup>Enosim Bio-tech Co., Ltd, Taiwan; <sup>3</sup>Plant Technology Research Center, Agricultural Technology Research Institute, Taiwan

**Emerging Technologies for Environmental Sensing and Monitoring**

Date: Tuesday, September 26, 2023

Time: 14:00 - 15:30

Room: Room 1

Chair(s): Morgan Madec, University of Strasbourg  
Paolo Motto Ros, Politecnico di Torino

**Machine Learning Models Comparison for Water Stress Detection Based on Stem Electrical Impedance Measurements** ..... 108

Federico Cum, Stefano Calvo, Danilo Demarchi, Umberto Garlando

Politecnico di Torino, Italy

**Mapping Micro-Climate in a Greenhouse Through a Context-Aware Recurrent Neural Network** ..... 113

Elia Brentarolli, Sara Migliorini, Davide Quaglia, Claudio Tomazzoli

Università degli Studi di Verona, Italy

**UAV-Based Realtime Communication Architecture for Forest Monitoring Using 5G** ..... 118

Nasrin Ghadami Vaghalandari, Kai Daniel, Shervin Samadi, Daniel Kurzer

University of Siegen, Germany

**Mask R-CNN Based Automated Detection of Mushrooms in Natural Environments** ..... 123

Christos Charisis<sup>1</sup>, Konstantinos Karantzas<sup>2</sup>, Dimitrios Argyropoulos<sup>1</sup>

<sup>1</sup>University College Dublin, Ireland; <sup>2</sup>National Technical University of Athens, Greece

**Advances in Design and Construction of Leaf Wetness Sensors** ..... 128

Elena Filipescu, Giovanni Paolo Colucci, Daniele Trincherò

Politecnico di Torino, Italy

**Evaluation of a Low-Cost Soil Moisture and EC Sensor in Different Soil Types** ..... 132

Vamsee Krishna Bodasingi, Bakul Rao, Harish K. Pillai

Indian Institute of Technology Bombay, India

# IoT Innovations for Smart Agriculture and Sustainable Food Production

Date: Wednesday, September 27, 2023  
Time: 8:30 - 10:00  
Room: Room 1  
Chair(s): Alessandro Sanginario, Politecnico di Torino  
Jai Narayan Tripathi, Indian Institute of Technology Jodhpur

## Energy Efficient, Secure and Spectrum Aware Ultra-Low Power Internet-of-Things System Infrastructure for Precision Agriculture ..... 137

Ankit Mittal, Ziyue Xu, Aatmesh Shrivastava  
*Northeastern University, United States*

## Participatory Development in Indigenous Rural Schools for Adopting IoT in Agrifood ..... 142

Carlos Muñoz P.<sup>1</sup>, Juan Ignacio Huircan Q.<sup>1</sup>, Doris Saez H.<sup>2</sup>, Rosa Medina D.<sup>3</sup>, Oscar Poblete<sup>2</sup>, Oscar Villagra<sup>1</sup>, Bryan Cartes<sup>1</sup>, Josefa Silva<sup>1</sup>, Matías Alegría<sup>2</sup>  
*<sup>1</sup>Universidad de La Frontera, Chile; <sup>2</sup>Universidad de Chile, Chile; <sup>3</sup>Universidad de Concepción, Chile*

## A Model for a Dense LoRaWAN Network in the Agribusiness ..... 147

Alfredo Arnaud<sup>1</sup>, Maria Eugenia Araújo<sup>1</sup>, Ariel Dagnino<sup>1</sup>, Joel Gak<sup>1</sup>, Aaron Jiménez<sup>2</sup>, Jose Job Flores<sup>1</sup>, Matias Miguez<sup>1</sup>, Luis Arturo Soriano<sup>2</sup>  
*<sup>1</sup>Universidad Católica del Uruguay, Uruguay; <sup>2</sup>Universidad Autónoma de Chapingo, Mexico*

## Ochratoxin A Growth Probability Estimation in Wine Production Using AI-Powered IoT Devices ..... 152

Mohamed Riad Sebti, Sonia Carabetta, Mariateresa Russo, Massimo Merenda  
*Università degli Studi Mediterranea di Reggio Calabria, Italy*

## A OpenThread WSN Prototype for the Monitoring of Crops ..... 157

Vasco Fabiani<sup>1</sup>, Maurizio Palmisano<sup>2</sup>, Alessandro Checco<sup>1</sup>, Davide Polese<sup>3</sup>  
*<sup>1</sup>Università di Roma La Sapienza, Italy; <sup>2</sup>Istituto per i Sistemi Agricoli e Forestali del Mediterraneo Consiglio Nazionale delle Ricerche, Italy; <sup>3</sup>Istituto per la Microelettronica e Microsistemi Consiglio Nazionale delle Ricerche, Italy*

## A Wireless Biosensor for In-Vivo and Real-Time Plant Monitoring for Smart Agriculture ..... 162

Michele Caselli<sup>1</sup>, Edoardo Graiani<sup>1</sup>, Valentina Bianchi<sup>1</sup>, Filippo Vurro<sup>2</sup>, Manuele Bettelli<sup>2</sup>, Ilaria De Munari<sup>1</sup>, Michela Janni<sup>2</sup>, Andrea Boni<sup>1</sup>  
*<sup>1</sup>Università degli Studi di Parma, Italy; <sup>2</sup>Institute of Materials for Electronics and Magnetism, National Research Council, Italy*

# Advancements in Agricultural Water Management and Monitoring

Date: Wednesday, September 27, 2023  
Time: 10:30 - 12:00  
Room: Room 1  
Chair(s): Marco Carminati, Politecnico di Milano  
Luis Kun, President IEEE Society on Social Implications of Technology

## Long-Range Low-Power Electronic System for Drip Irrigation in Precision Agriculture ..... 167

Mattia Barezzi<sup>1</sup>, Francesca Pettiti<sup>2</sup>, Luca Nari<sup>2</sup>, Davide Gisolo<sup>1</sup>, Davide Canone<sup>1</sup>, Danilo Demarchi<sup>1</sup>, Umberto Garlando<sup>1</sup>

<sup>1</sup>Politecnico di Torino, Italy; <sup>2</sup>Fondazione Agrion, Italy

## Comparison of Moisture Controllers for Blueberries Based on Hydrodynamic Parameters of the Substrate ..... 172

Manuel Gantiva-Osorio, Alexander Pérez-Ruiz, Javier Alberto Chaparro

Escuela Colombiana de Ingeniería Julio Garavito, Colombia

## Optimal Operation Points for Long-Term Partial Nitrification in CSTR for Dairy Wastewater Treatment: A Simulation Study ..... 177

Carlos Muñoz Poblete<sup>1</sup>, Christian Antileo Hernández<sup>1</sup>, Pedro Cachaña Seguel<sup>1</sup>, Francisco Jaramillo Montoya<sup>2</sup>

<sup>1</sup>Universidad de La Frontera, Chile; <sup>2</sup>Universidad de Chile, Chile

## Paper-Based Impedimetric Sensor for On-Plant Humidity and Transpiration Monitoring ..... 182

Sahira Vasquez Baez<sup>1</sup>, Pietro Ibba<sup>1</sup>, Antonio Altana<sup>1</sup>, Martina Aurora Costa Angeli<sup>1</sup>, Almudena Rivadeneyra<sup>2</sup>, Paolo Lugli<sup>1</sup>, Luisa Petti<sup>1</sup>

<sup>1</sup>Free University of Bozen-Bolzano, Italy; <sup>2</sup>University of Granada, Spain

## Water Leak Monitoring by Means of a Wireless Network of Impedance Sensing Nodes ..... 187

D.A. Carnevale Castillo, D.M. Crafa, C. Riboldi, M. Carminati

Politecnico di Milano, Italy

## Evaluation of Atmospheric Harvesting Solar Hydropanels in a Monitored Tropical Environment ..... 192

Anibal Ruíz-Barquero, Sergio Arriola-Valverde, Federico Masís-Meléndez, Ronny García-Ramírez, Alfonso Chacón-Rodríguez, Renato Rímolo-Donadío

Instituto Tecnológico de Costa Rica, Costa Rica