Innovative Agricultural Technologies Congress

IAT CONGRESS' 25

15-19 October 2025, Antalya - Türkiye

The meeting point of science

Abstract Book

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Preface

We are excited and honored to invite you to participate in the 15th International Congress of the Innovative Agricultural Technologies (IAT 2025), organized by Ankara University and Harper Adams University in Antalya, Turkey, from October 15-19, 2025.

The 25th IAT Congress aims to showcase the potential of innovative technologies in agriculture to improve sustainability and productivity while addressing digital agriculture. We are excited to bring together academics, researchers, engineers, industry partners, and students from around the world to share the latest results and insights in agricultural technology engineering. This congress provides a dynamic platform for keynote speeches, oral and poster presentations, special panels, online talks, and live discussions on a variety of topics. In addition to the sessions, we hope you enjoy Antalya's unique environment and hospitality during this special week of science and friendship.

The scientific program includes AI/ML and data science, IoT and cloud solutions, smart and digital agriculture, autonomous and robotic systems, computer and machine vision, smart sensors, UAVs and drones, controlled environment agriculture, post-harvest and processing innovations, water and energy technologies, blockchain and traceability, digital twins, RTK, greenhouse technologies, and more. Our goal is to foster interdisciplinary dialogue and drive practical solutions for resilient, productive, and sustainable agriculture-food systems.

We are proud to announce that contributions accepted after peer review will be published in a Springer Scopus-indexed conference proceedings book, and authors of selected papers will be invited to submit extended versions to the Computers and Electronics in Agriculture special issue titled "Food Safety and Food Affordability: Recent Developments." These publication channels demonstrate the conference's commitment to scientific rigor and impact.

We want to sincerely thank the conference chairs, our invited and keynote speakers, session chairs, Scientific Committee members, authors, colleagues, and Bilkon for their valuable contributions. We also thank Ankara University, Harper Adams University, Springer Nature, Elsevier, and our sponsors Vatan Plastik, Tuzeks, AISera, Ziraat Bank, Agrapar, and İren for supporting us in making this congress possible.

We wish you an inspiring congress and a memorable stay in Antalya.

With best regards,

On behalf of the IAT Congress' 25 Organizing Committee

Prof. Dr. Hasan Silleli, Co-Chair

Prof. Dr. Fernando Auat Cheein, Co-Chair

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Fernando Auat Cheein	Harper Adams University

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Da-Wen Sun	University College Dublin, Ireland

October 15, 2025, Wednesday	
14.00	**Check in to the Congress Hotel, Sherwood Exclusive Lara, Antalya**
14.00 – 17.00	**Registration**
19.00 – 21.00	**Dinner**

October 16, 2025, Thursday	
10.00 – 10:20	**Opening Ceremony** **Hasan Silleli,** Co-Chair, Ankara University, Türkiye **Fernando Auat Cheein,** Co-Chair, Harper Adams University, UK
10.20 – 10.50	**Taking Photos / Break**
Keynote Speaker Presentations (1-2)	
10.50 – 11.20	**KSP-1: Greenhouse Technologies and Management** **Nikolaos Katsoulas – University of Thessaly, Greece**
11.20 – 11.50	**KSP-2: Engineering a Path towards Sustainable Livestock Production Systems** **Tomás Norton – KU Leuven, Belgium**
11.50 – 12.10	**Presentation of Vatan Plastik Corporate, Main Sponsor**
12.10 – 13.30	**Lunch Break**

SESSION I – Oral Presentations (1-5)	
Chair: Chyngyz Erkinbaev – University of Manitoba, Canada	
13.30 – 13.45	**OP-1: Exploring the Use of Eye Tracking and Egocentric Vision for Human Performance Assessment in Fruit Harvesting** Andy Perrett, Francesco Del Duchetto, Sandy Willmott, Timothy Hodgson, Jack Grant, Louise Manning, **Leonardo Guevara**
13.45 – 14.00	**OP-2: Application of Blockchain in Greenhouse Data Management: A Case Study on Protecting Sensor Data Integrity** **Gokhan Erdemir**, Burak Ağgül, Erkan Kaplanoglu

14.00 – 14.15	**OP-3: From 3D Geometry and Spectral Intensity to Moisture Insight: LiDAR-Based Postharvest Quality Monitoring** Majharulislam Babor, Arman Arefi, Barbara Sturm, Marina M. C. Höhne, Manuela Zude-Sasse
14.15 – 14.30	**OP-4: Rapid Roboting: Building a Mobile Manipulator for Plant Monitoring** Ciaran Johnson, Christopher Quail, Garry Ellard, Steve Tonneau, Alistair McConnell, Fernando Auat Cheein
14.30 – 14.45	**OP-5: The Development of UK Agri-Robotics Regulatory Network** Sven Peets, Kit Franklin, Mark Rutter, Yaw Sarfo, Phillip Ironside, Mithun Poozhiyil, Alex Allan, Elizabeth Sklar
14.45 – 15.00	**Break**

SESSION II – Oral Presentations (6-11)	
Chair: Gokhan Erdemir – The University of Tennessee, USA	
15.00 – 15.15	**OP-6: A Robotic Livestock Feed Consumption Monitoring System for Dairy Farm** Reza Ehsani, Arash Toudeshki
15.15 – 15.30	**OP-7: Physically Realistic Digital Replica of Strawberry Plants for Robotic Harvesting** Luis Herrera, Juan Pablo Espejel Flores, Luis Arturo Soriano Avendaño, Grzegorz Cielniak, Leonardo Guevara, Abdurrahman Yilmaz
15.30 – 15.45	**OP-8: Development of an IoT-based Smart-Shelf for Real-Time Quality Monitoring of Plant-Based Food** Chyngyz Erkinbaev
15.45 – 16.00	**OP-9: Behavioral and Structural Profiles of Precision Agriculture Uptake among Italian Winegrowers** Adriano Biondo, Antonino Galati, Francesco Caracciolo
16.00 – 16.15	**OP-10: Vegetation Indices Including Soil Confound Plant Health and Canopy Cover: Multi-environment Analysis of Maize Temporal Progression** Fatma Ozair, Aaron DeSalvio, Mustafa Arik, Alper Adak, Seth Murray
16.15 – 16.30	**OP-11: Development of Large-scale Machine Vision System and Synchronization with Optimized Nozzle Control for Spot Application on Colorado Potato Beetle** Ahmad Al-Mallahi, Imran Hassan, Mozammel Bin Motalab, Humphrey Maambo, Alimohammad Shirzadifar
16.30– 17.00	**Poster Session**

October 17, 2025, Friday	
Keynote Speaker Presentations (3-4)	
10.00 – 10.30	**KSP-3: Recent Advances in Radio Frequency Heating Technologies for Disinfesting, Pasteurizing and Drying Agricultural Products** **Shaojin Wang – Northwest A&F University, China**
10.30 – 11.00	**KSP-4: Advancing Plant Proteins for a Sustainable Planet** **Jitendra Paliwal – University of Winnipeg, Canada**
Expert Panel on Digital & Precision Agriculture	
Chair: Fernando Auat Cheein – Harper Adams University, UK	
11.00 – 12.30	**Barbara Sturm,** Editor-in-Chief of Thermal Science and Engineering Process, Agricultural Engineering in Bioeconomic Systems at Humboldt-Universität zu Berlin, Germany **Francesco Marinello,** Editor-in-Chief of Computers and Electronics in Agriculture, University of Padova, Italy **Redmond Shamsiri,** Neubrandenburg University of Applied Sciences, Germany **Spyros Fountas,** Editor-in-Chief of Smart Agricultural Technology, Agricultural University of Athens, Greece
12.00 – 13.30	**Lunch Break**
SESSION III – Oral Presentations (12-18)	
Chair: Leonardo Guevara – University of Lincoln, UK	
13.30 – 13.45	**OP-12: Hyperspectral Band-Selection for Vegetation Health Monitoring Using Explainable Models** Juan Sebastian Estrada, Fernando Auat Cheein
13.45 – 14.00	**OP-13: Mapping the Spatial Evolution of Drift-Prone Droplets from Agricultural Nozzles under Wind Tunnel Conditions** Mehrzad Ansaripour, Reza Alidoost Dafsari, Seung-Hwa Yu, Jeekeun Lee

14.00 – 14.15	**OP-14: Automation of Section Control of Agricultural Sprayer with AgOpenGPS Platform** Petri Linna, Hannu Haapala
14.15 – 14.30	**OP-15: Deep Eutectic Solvent Pre-treatment of Common Reed – A Techno-Economic and Environmental Assessment** Jana Schultz, Asli Isci, Martin Kaltschmitt
14.30 – 14.45	**OP-16: Wind Tunnel-Based Development of an Airborne Drift Potential Index for Agricultural Spray Nozzles** Mehrzad Ansaripour, Reza Alidoost Dafsari, Chungu Lee, Seung-Hwa Yu, Jeekeun Lee
14.45 – 15.00	**OP-17: Megaweeds: an Experimental Study on Weed Detection with YOLOv7 using a Novel Dataset** Sophie Wildeboer, Jurrian Doornbos, Önder Babur, Kwabena Bennin
15.00 – 15.15	**OP-18: Driving Sustainability: A Life Cycle Emissions Analysis of Multi-Purpose Tractors in Turkey** İdil Öğretim Ünver, Hakan Mencek

COMPAG Special Issue Session	
Chair: Ferruh Erdoğdu – Ankara University, Türkiye	
15.30 – 16.30	**Tomás Norton** – KU Leuven, Belgium **Shaojin Wang** – Northwest A&F University, China **Jitendra Paliwal** – University of Winnipeg, Canada
16.30 – 17.00	**Poster Session**

October 18, 2025, Saturday

Keynote Speaker Presentations (5-7)	
09.30 – 10.00	**KSP-5: Acquisition and Use of 3D Crop Data in Precision Agriculture** **Àlex Escolà Agustí – Universitat de Lleida, Agrotecnio CERCA Center, Spain**
10.00 – 10.30	**KSP-6: Low-cost Orchard Monitoring Systems Using Photonic Sensors** **Eduard Gregorio López – Universitat de Lleida, Spain**
10.30 – 11.00	**KSP-7: Responsible Agricultural Robotics: Moving beyond Techno-optimism for Sustainable and Just Transitions** **David Christian Rose Harper Adams University, UK**

SESSION IV – Oral Presentations (19-23)	
Chair: Sven Peets – Harper Adams University, UK	
11.00 – 11.15	**OP-19: Valorization of Olive Tree Pruning Waste via Different Pretreatment Strategies: Unlocking Valuable Compounds for Integrated Biorefinery Applications** Asli Isci, Simel Bagder Elmaci, Miyase Deniz Çam, Dicle Delal Aslanhan, Ozge Sakiyan, Irfan Turhan
11.15 – 11.30	**OP-20: Assessment of Olive Tree – Legume Crops Intercropping with Respect to Agronomic Traits and Economic Impact in Mediterranean Climate Conditions** Moin Qureshi, Hüseyin Çancı, Asli Isci, İrfan Turhan, Engin Yol
11.30 – 11.45	**OP-21: High-Resolution Leaf Tracking for Real-World Crop Phenotyping: Introducing CanolaTrack and LeafTrackNet** Shanghua Liu, Majharulislam Babor, Christoph Verduyn, Breght Vandenberghe, Bruno Parodi, Cornelia Weltzien, Marina Höhne
11.45 – 12.00	**OP-22: Using Deep Learning to Detect Pea Root Nodules within a Complex Soil Media Background** Faith Akinyemi, Michael Beck, Christopher Bidinosti, Christopher Henry, Zhigang Liu, Allan Feurtado, Shengjian Ye, Muhammad Rizwan
12.00 – 12.15	**OP-23: Exploring the Geocooling Potential of Agricultural Greenhouses in Desert Climates: The Case of Southern Morocco** Zouhair Charqui, Mohammed Ouikhalfan
12.15 – 13.30	**Lunch Break**

SESSION V – Oral Presentations (24-29)	
Chair: Lenka Langhansová – Czech Academy of Sciences, Czechia	
13.30 – 13.45	**OP-24: Hazelnut (Corylus avellana L.) Mass Prediction Using Machine Learning Models Based on Physical Attributes** Geofrey Prudence Baitu, Omsalma Alsadig Adam Gadalla, Yeşim Benal Öztekin, Khaled Adil Dawood Idress, Mohammedeltayib Omer Salih Eissa
13.45 – 14.00	**OP-25: Classification of Hazelnut Cultivars Using Attention-Enhanced Deep Learning Models** Geofrey Prudence Baitu, Yeşim Benal Öztekin, Omsalma Alsadig Adam Gadalla, Khalid Adil Dawood Idress, Mohammedeltayib Omer Salih Eissa
14.00 – 14.15	**OP-26: MobileNetV2-Driven Image Recognition for Discriminating Pistachio Varieties: Akuri, Antep, Halebi, Kırmızı, and Tekin** Mohammedeltayib Omer Salih Eissa, Yeşim Benal Öztekin, Khaled Adil Dawood Idress, Geofrey Prudence Baitu, Omsalma Alsadig Adam Gadalla
14.15 – 14.30	**OP-27: Deploying MobileNetV2 on Edge Impulse for Hazelnut Quality Inspection** Khaled Adil Dawood Idress, Mohammedeltayib Omer Salih Eissa, Geofrey Prudence Baitu, Omsalma Alsadig Adam Gadalla, Yeşim Benal Öztekin
14.30 – 14.45	**OP-28: Potential for Pre-Harvest Prediction of Tuber Potato Physiological Disorders** Edwin Toreveyi, Peter Kettlewell, Jim Monaghan, Nicola Randall, Joseph Mhango
14.45 – 15.00	**OP-29: A Novel Agricultural Spraying Aerial Robot (AgRoHedral): Performance Improvement in the Presence of Sloshing Effect** Ali Kafili Gavgani, Ali Talaiezadeh, Aria Alasty, Hossein Nejat Pishkenari

SESSION VI – Oral Presentations (30-36) – Hall B	
Chair: Ahmet Çolak – Ankara University, Türkiye	
15.30 – 15.45	**OP-30: End-of-Line Traceability of Dried Jujube: Classifying Microwave Power Levels and Ultrasound Pretreatment with CNNs** Banu Ulu, Necati Çetin, Burak Ulu, Kamil Saçılık, Seda Günaydın, Ahmet Çolak
15.45 – 16.00	**OP-31: Optimization and Performance of an Artificial Intelligence-Based Greenhouse Dryer** Gizem Het Battal, Kamil Saçılık
16.00 – 16.15	**OP-32: Response of Soybean Forage Yield and Quality to Varying Irrigation Levels** Emre Akkaya, İhsan Serkan Varol, Mahmut Kaplan

16.15 – 16.30	**OP-33: Design and Preliminary Evaluation of an Integrated Nondestructive Grain Moisture Sensing System for Digital Agriculture** Kamil Saçılık, Necati Çetin, Ahmet Aktaş, Burak Özbey
16.30 – 16.45	**OP-34: Water Stress Impacts on Soybean Growth, Yield, and Water Use Efficiency in Semi-Arid Regions** Emre Akkaya , Ihsan Serkan Varol, Mahmut Kaplan
16.45 – 17.00	**OP-35: Deep Learning-Based Fruit Detection in Apple Orchards for PLC-Based Regional Spraying** Necati Çetin, Burak Ulu, Omer Faruk Ergin, Banu Ulu, Aydın Uzun, Şahin Yıldırım
17.00 – 17.15	**OP-36: Prediction of Soluble Solids Content in Sweet Cherries Using Dielectric Spectroscopy with Convolutional Neural Network** Kamil Saçılık, Mehmet Akif Buzpınar, Erhan Kavuncuoğlu, Necati Çetin
17.15 – 17.30	**OP-37: Determining The Effects of Evaporative Cooling System in Tractor Engine and PTO Performance Tests** S. Oğuz Yıldız, Hasan H. Silleli

IAT Congress Special Panel	
Chair: Fernando Auat Cheein – Harper Adams University, UK	
15.30 – 17.00	**Nikolaos Katsoulas** – University of Thessaly, Greece **Àlex Escolà Agustí** – Universitat de Lleida, Agrotecnio CERCA Center, Spain **Hasan Silleli** – Ankara University, Türkiye
16.30 – 17.15	**Poster Session**

	Poster Presentations Session
	PP-1: Valuable Compound Recovery from Oak Biomass: A Comparative Study of Pretreatment Techniques **Aslı Isci**, Simel Badger Elmaci, Dicle Delal Aslanhan, Miyase Deniz Çam, Ozge Şakıyan
	PP-2: Optimizing Recirculating Aquaculture System Effluent for Lettuce Production: Nutrient Content and Plant Quality **Lenka Langhansova**, Veronika Tumova, Šárka Petrova, Radka Podlipna, Martin Liška, Daniel Haisel, Pavel Klouček, Miroslav Petrtýl
	PP-3: Beyond Speed: A Comparative Study on Human Performance and Robotic Potential in Strawberry Harvesting **Jack Grant**, Andy Perrett, Francesco Del Duchetto, Sandy Willmott, Timothy Hodgson, Louise Manning, Leonardo Guevara

	PP-4: Health and Safety Risks of Fresh Meat in Retail **Taha Rababah**
	PP-5: Agronomic Response of Horticultural Crops Under Agrivoltaic Systems: First Insights from a Mediterranean Climate **Ramón Salcedo**, Irma Roig-Vilanova, Gil Gorchs, Nuria Carazo, Anna Gras, David Caballero, Cecilio Angulo, James McDonalds, Marcel Macarulla
	PP-6: Design and Performance Evaluation of Sustainable Duster Equipment Prototype for Sulfur Based Plant Protection in Date Palm Trees Radhwan Mohammad, **Majid Alheidary**
	PP-7: CMD-YOLO: A Rapid Classification and Recognition Model for Chili Fruit Maturity Integrating Lightweight Design and Multi-Scale Feature Enhancement Minqiu Kuang, **Xu Li**, Shang Chen
	PP-8: Smart Sensing for Food Quality Assessment: Integration of Multimodal Data and Model Fine-Tuning Angshuman Thakuria, **Chyngyz Erkinbaev**

October 19, 2025, Sunday

09.00-12.00 **Free time for Sightseeing in Antalya**

Invited Keynote Presentations

Oral Presentation Abstracts

Poster Abstracts

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Invited Speakers Presentations

KSP-01. Greenhouse Technologies and Management

Nikolaos Katsoulas[1,2]*

[1] University of Thessaly, Department of Agriculture Crop Production and Rural Environment, Laboratory of Agricultural Constructions and Environmental Control, Volos, Greece
[2] Mediterranean Horticultural Center PC, University of Thessaly-Spin-off, Karditsa, Greece

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Abstract

This keynote will make an effort to highlight the recent trends in greenhouse technologies and management, with focus on solutions that aim to optimal use of inputs, enhancement of sustainability of the greenhouse sector and in reduction of environmental footprint. Some of the current trends in greenhouse technology and management are related to data collection, processing and use, system and material development, process coupling and robotics. Data collected from different sources, such as climate control systems, hardware sensor measurements, cameras, soft-sensor estimates, crop and labour task monitoring, are used for decision making and control of greenhouse conditions, crop growth, and mass and energy transfer processes. From greenhouse climate control to irrigation fertilisation and disease management strategy, more and more decisions require some degree of data processing. On the other hand, new systems are being developed that mainly aim to save energy and water, and new methods of greenhouse control and crop management are researched and gradually put into practice. Aiming to maximize the use of available resources, technologies are being developed that allow the coupling of different processes, such as the production of electricity, heat and cooling energy, or the coupling of different production processes, such as production of electrical energy in combination with production of agricultural products. The use of renewable energy sources, especially photovoltaics, further reduces the need of fossil fuels and mitigates greenhouse gas emissions. Robotic applications for labour-intensive tasks such as planting, harvesting, and monitoring are applied targeting to increase the efficiency, reduce the operational costs and mainly reduce the uncertainty related to the lack of qualified personnel. The development of new technologies, such as those noted above, aim at a more efficient production process. However, the type of technology and the degree of its integration in specific greenhouse projects is a critical question, which does not have a simple answer, as it depends on the specific technical, economic and social conditions.

Keywords: Greenhouse microclimate, energy saving, water use efficiency, crop monitoring, soft sensors

KSP-02. Engineering a Path towards Sustainable Livestock Production Systems

Tomás Norton[1]*

[1] Department of Biosystems, Division M3-BIORES: Measure, Model & Manage Bioresponses, Catholic University of Leuven, Kasteelpark Arenberg 30, 3001 Heverlee, Belgium

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Abstract

Modern livestock farming is going through a period of rapid evolution. Farmers are now expected to balance efficient food production with a growing focus on animal welfare, sustainability, circularity and biodiversity. Various (bio)technologies are becoming essential to help farmers meet these complex new challenges. Precision Livestock Farming (PLF) technologies are evolving from simple early warning systems to sophisticated, fully automated solutions. These tools are critical for enhancing productivity and sustainability by reducing uncertainty in animal production and enabling greater automation. This presentation will chart the trajectory of PLF technology, highlighting the progress beyond the state of the art that various PLF research projects have made over recent years. The overall aim of the talk is to underscore the opportunities for agricultural and biosystems engineers in shaping the field of sustainable livestock production.

Keywords: Precision Livestock Farming (PLF), animal welfare, sustainable production, automation, data-driven management.

KSP-03. Recent Advances in Radio Frequency Heating Technologies for Disinfesting, Pasteurizing and Drying Agricultural Products

Shaojin Wang[1]*

[1] College of Mechanical and Electronic Engineering, Northwest A&F University, Yangling, Shaanxi, 712100, China

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Abstract

Recent pathogen incidents, increased regulations on fumigants, and green technology requirements have forced agricultural product industry to seek physical alternatives for effective postharvest processing of agricultural products. Radio frequency (RF) energy has been identified as one potential treatment method to replace chemical fumigations and other conventional thermal methods because it is relatively easy to apply and leave no chemical residues. RF equipment is commercially available today, and is commonly used by the baking industry for final drying of crackers and by other industries. It involves the direct transfer of electromagnetic energy into bulk materials, initiating fast and volumetric heating. This presentation introduces the RF heating principle and systems, advantages and disadvantages, explores the difference between free running oscillator and 50 Ω systems, and finally demonstrates some recent developments and applications of RF systems for drying, disinfestations and pasteurization of agricultural products, including system safety, top electrode voltage determinations of the RF systems, industrial applications of RF disinfestations for walnuts and milled rice, new small scale RF system development and RF heating uniformity improvements using computer simulation. Finally, the current problems and recommendations for future work related to RF processing of agricultural products are proposed. This presentation would enhance the understanding of RF heating for agricultural products and promote the further applications of RF technology in the food industry.

Keywords: Heating uniformity; radio frequency energy; disinfestation; drying; pasteurization

KSP-04. Advancing Plant Proteins for a Sustainable Planet

Chitra Sivakumar[1], Jitendra Paliwal[1,2]*

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[2] Department of Applied Computer Science, The University of Winnipeg, 515 Portage Avenue, Winnipeg, Manitoba, R3B 2E9, Canada

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Abstract

This review provides an in-depth and comprehensive analysis of food proteins, focusing particularly on the comparative evaluation of plant- and animal-based sources in terms of their nutritional attributes, processing methodologies, consumer perceptions, and environmental impacts. The growing global demand for sustainable and nutritionally adequate protein sources has intensified interest in plant-based alternatives. Accordingly, this review critically examines the viability of plant proteins as substitutes for animal proteins within both nutritional and sustainability contexts.

Animal proteins are widely recognized for their complete amino acid profiles, high digestibility and bioavailability, which make them essential components of many traditional diets. However, their production is linked to considerable ecological burdens, including high greenhouse gas emissions, extensive land and water use, and potential health implications associated with excessive consumption of red and processed meats. Conversely, plant proteins offer more environmentally sustainable solutions but present several nutritional and functional challenges. These include incomplete amino acid compositions, lower digestibility, and the presence of anti-nutritional compounds that can hinder nutrient absorption. Sensory drawbacks, such as undesirable flavours, aromas, and textural inconsistencies, further affect consumer acceptance and market growth.

Recent advancements in food processing technologies, including protein isolation, fermentation, enzymatic modification, and extrusion, have significantly improved the functional properties and nutritional quality of plant proteins. Nonetheless, achieving complete equivalence to animal proteins remains a complex challenge due to inherent biochemical and structural differences. Moreover, cultural preferences, socioeconomic conditions, and behavioural factors continue to shape global protein consumption trends, complicating the transition toward more plant-based diets.

By integrating technical, environmental, and consumer perspectives, this review provides a holistic overview of the evolving protein landscape. It underscores the importance of aligning scientific innovation with consumer education, policy initiatives, and targeted marketing to develop protein alternatives that are nutritionally balanced, environmentally sustainable, and socially acceptable.

Keywords: Plant proteins, animal proteins, digestibility, consumer acceptance, carbon footprint, sustainability

KSP-05. Acquisition and use of 3D Crop Data in Precision Agriculture

Àlex Escolà Agustí[1]*

[1] Universitat de Lleida, Agrotecnio CERCA Center, Catalonia, Spain

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Abstract

Some time ago, obtaining geometric and structural data of crops was tedious, time-consuming and expensive. Fortunately, the evolution of agricultural technology in recent years has partly overcome those difficulties and provides farmers and advisors with the possibility to gather 3D data of crops such as canopy height, width, thickness, leafiness, porosity, etc. at a reasonable cost. Lamentably, there is no universal solution as all technologies have their own pros and cons. Ultrasounds, light detection and ranging, digital aerial and terrestrial photogrammetry and RGB-D cameras are the principal technologies used to retrieve such data from crops. However, they all need important postprocessing to convert data into information, and experience and agronomy to convert information into knowledge to be used in the decision-making process in the context of Precision Agriculture.

3D data could be used to monitor crops accounting for variability in their development as a proxy of biotic and/or abiotic stress detection and quantification. Moreover, the detected variability could also be used to create management zones within each field for variable-rate application of agricultural inputs such as fertilisers, irrigation, plant protection products and seeds.

In this keynote, the evolution and the state-of-the-art of 3D data acquisition systems will be described and many examples of commercial and research solutions will be provided for the attendees to have an idea of what could the trends and challenges be in the coming years.

Keywords: 3D data, lidar, photogrammetry, RGB-D, variability, crop canopy

KSP-06. Low-cost Orchard Monitoring Systems using Photonic Sensors

Eduard Gregorio López[1,2]*

[1] Research Group on AgroICT & Precision Agriculture,

[2] Universitat de Lleida – Agrotecnio CERCA Center, Lleida, Catalonia, Spain

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Abstract

In recent years, fruit growing has benefited from the development of accurate monitoring systems based on photonic sensors. Two key applications are the geometric and structural characterization of fruit trees, as well as in-field fruit detection and sizing.

Among the methods used to characterize fruit trees, conventional LiDAR (Light Detection and Ranging) sensors stand out due to their high performance and robustness in outdoor environments. However, their complexity and high cost pose significant barriers to adoption in the fruit-growing sector. This keynote explores the use of affordable solid-state LiDAR sensors which, combined with SLAM (Simultaneous Localization and Mapping) techniques, could offer a promising alternative.

Counting the number of fruits on the trees is important for many applications, including yield prediction, yield mapping, and automated harvesting. Typically, automatic fruit detection has relied on RGB images, which face significant limitations due to factors such as occlusions and varying lighting conditions. The availability of new photonic sensors, together with significant advances in artificial intelligence, has enabled major progress not only in fruit detection but also in locating fruits within the tree and estimating their size. This keynote reviews various studies that use multiple technologies, including LiDAR, structure-from-motion, and RGB-D cameras, for in-field fruit detection and sizing.

The current challenge is to transfer all this technology to farmers and thereby contribute to more sustainable fruit production in social, economic, and environmental terms.

Keywords: Tree geometry, fruit detection, fruit sizing, LiDAR, RGB-D camera, photogrammetry

KSP-07. Responsible Agricultural AI: Moving beyond Techno-Optimism for Sustainable and Just Transitions

David Christian Rose[1]*

[1] Elizabeth Creak Chair in Sustainable Agricultural Change, Harper Adams University, UK

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Abstract

Artificial intelligence and other precision technologies are widely hailed in policy and media documents as potentially transformative technologies for sustainable agriculture. However, research from the social sciences illustrates that emergent technologies hold risks as well as opportunities for people, production, and the planet. Using a just transitions framework, this talk highlights the potential risks associated with some precision technologies, drawing on case studies about the use of LLMs in agricultural extension, autonomous robotics in the crop sector, as well as precision technologies in livestock farming. It explores how proper integration of the social sciences from the start of inter-disciplinary projects can help to cut through unhelpful techno-optimism and create the conditions for the development and scaling of responsible and just technologies.

Keywords: AI, automation, ethics, just transition, precision, responsible innovation

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The meeting point of science

Oral Presentations

OP-01. Exploring the Use of Eye Tracking and Egocentric Vision for Human Performance Assessment in Fruit Harvesting

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Abstract

Eye tracking and egocentric vision technologies have emerged as powerful tools for analysing human behaviour, offering deep insights into attention patterns, decision-making processes, and mental workload. These tools have been successfully applied in diverse fields such as medicine, marketing, and human-computer interaction, yet their potential remains largely unexplored in the agricultural domain. Thus, this study investigates for the first time the feasibility and effectiveness of leveraging eye tracking and egocentric video analysis to assess human performance in soft fruit harvesting tasks, specifically focusing on strawberry as a use case. This work employs mobile eye-tracking glasses worn by workers as they navigate dynamic farm settings. The unstructured and fast-paced nature of harvesting, along with the small size of fruits and their frequent overlap with other objects, makes the annotation of the resultant eye-tracking data complex and time-consuming. To address this problem, this work introduces an egocentric vision system designed to automate the spatial and temporal annotation of key events and interactions relevant to fruit harvesting. Validated with field recordings of professional pickers, the system achieved substantial inter-rater agreement with human coders (mean Fleiss' kappa score of 0.692 with a standard deviation of 0.06). Moreover, when fine-tuning its behaviour to match human manual annotations, the automatic reached an average accuracy of 0.845 with an average F1 score of 0.735. These results show that the system generates annotations with accuracy comparable to that of human coders while reducing processing time from several hours to just minutes, demonstrating its potential for scalable use in agricultural labour analysis and training.

Keywords: Eye tracking, egocentric vision, computer vision, fruit harvesting,·strawberry harvesting, agriculture 5.0

OP-02. Application of Blockchain in Greenhouse Data Management: A Case Study on Protecting Sensor Data Integrity

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Abstract

Where agricultural production is of critical importance and even plays a significant role in international politics, the issue of information security has become prominent at every stage of agricultural production in this century. While traditional farming practices do not pose a problem for information security, on the other hand, data security, accuracy, integrity, and reliability for decision-making are critical for new-generation smart farming systems. Data used in greenhouse management, in particular, must be highly accurate, tamper-proof, and unalterable, because systems such as temperature, irrigation, humidity, and light control are controlled by sensor data. Robust and stable control can only be achieved with accurate data. Even small amounts of malicious or spoofed sensor data can disrupt operations, cause material damage, delay production, and lead to significant financial losses. Ensuring secure and robust data flow is crucial not only for sensor data but for all IoT-based devices and systems. This study proposes a blockchain-based data management framework for greenhouse environments to address these challenges. The system integrates IoT-enabled control units with heterogeneous sensor networks and uses smart contracts to ensure secure, auditable, and tamper-resistant data transmission. By leveraging blockchain's decentralized and immutable ledger, the proposed approach enhances sensor data integrity, security, and trustworthiness. Experimental results from a greenhouse prototype demonstrate that the system achieves low energy consumption and fast transaction times while maintaining strong security guarantees. These findings highlight blockchain's potential to strengthen cyber-physical resilience in precision agriculture and contribute to the development of scalable and trustworthy smart farming ecosystems.

Keywords: Blockchain, smart farming, IoT security, sensor data integrity, greenhouse management

OP-03. From 3D Geometry and Spectral Intensity to Moisture Insight: LiDAR-Based Postharvest Quality Monitoring

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Abstract

Moisture content of horticultural produce is a decisive parameter of postharvest quality, as both food safety and shelf life depend on it. However, non-invasive approaches capable of monitoring entire products remain limited. Most existing techniques capture spectral or 2D spatial cues, overlooking the structural heterogeneity that is driven by drying dynamics. Here, the first annotated 3D LiDAR dataset, consisting of geometric and radiometric data, for postharvest moisture classification is introduced, comprising broccoli and mushroom samples recorded at multiple drying stages. Each sample includes geometric coordinates and corresponding wavelength-specific intensity at 1320 nm, 1450 nm, and a normalized moisture index. The LiDAR point clouds are paired with gravimetrically measured ground-truth moisture classes — high (>88 %), medium (35–88 %), and low (<35 %) — measured separately for core and periphery segments of each sample.

Using a PointNet++ framework with 10-fold cross-validation, based on geometry and the corresponding intensity at 1320 nm achieves classification accuracies of 89 % for broccoli, 87 % for mushroom, and 86 % for the combined dataset. At 1450 nm, performance increases to 90 % for broccoli, 87 % for mushroom, and 92 % for combined dataset. The moisture index yields 87 % for broccoli, 93 % for mushroom, and 85 % for combined dataset. Geometry alone provides limited discriminability between classes but increases robustness in predictions under structural variability, while combining geometry and intensity consistently produces the most reliable performance. Geometric augmentation strategies (random rotation, scaling, and jittering) further enhance generalization, improving accuracy by 4–18 %.

Spatial transfer experiments, considering the heterogeneous structure of products, reveal a clear asymmetry: models trained on dense, isotropic core segments generalize to irregular peripheries, but performance drops when models are trained on periphery segments and tested on cores. Under core-to-periphery transfer at 1450 nm, accuracy peaks at 98 % for broccoli, 90 % for mushroom, and 86 % in combined dataset. In contrast, periphery-to-core transfer drops to 88 % for broccoli, 63 % for mushroom, and 69 % in combined dataset. Modality analysis further shows that models trained on

core segments rely predominantly on geometry, whereas models trained on periphery segments require both geometry and intensity. Together, these results establish LiDAR as a scalable, non-invasive monitoring technology in precise postharvest inspection.

Keywords: Non-invasive food monitoring, postharvest, LiDAR, moisture classification, spatial generalization

OP-04. Rapid Roboting: Building a Mobile Manipulator for Plant Monitoring

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Abstract

Developing and deploying mobile manipulators remains a significant challenge for researchers without access to industrial-grade hardware or fabrication expertise. This paper presents a modular, low-cost platform for constructing a field-capable mobile manipulator using off-the-shelf components and open-source software. Designed with accessibility in mind and for plant or crop monitoring purposes, the platform enables researchers with limited mechanical or electrical engineering backgrounds to build, simulate, and control a mobile robotic system capable of manipulation and navigation in outdoor environments. The system is built around the Robot Operating System (ROS) Noetic and includes a complete Dockerised software stack, simulation tools, and real-time control interfaces. A full bill of materials, assembly guidance, and calibration steps are provided, alongside upgrade suggestions for extending system capabilities. This work aims to lower the barrier to real-world robotics research by offering a reproducible and extensible foundation for experimental development in field robotics.

Keywords: Field robotics, mobile manipulator, prototype, ROS, crop monitoring

OP-05. The Development of UK Agri-Robotics Regulatory Network

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Abstract

The current landscape of regulation and standards governing UK agri-robotics is complex, fragmented and opaque, which reduces confidence and slows innovation, adoption, investment and scaling. In the absence of a single regulator or policy maker to this growing sector the goal of the project is to establish the UK Agri-Robotics Regulatory Network (ARRNet) which focuses on unique challenges of the agri-robotics: in-field, outdoor settings with unpredictable and uncontrollable factors (e.g. weather and terrain) and a diverse cross-section of autonomy levels, spanning teleoperated and fully autonomous field robots. This network will become a trusted partner to regulators, policymakers, researchers and industry (from robotics developers to farmer end-users), delivering evidence to support progressive regulation, building cohesion to develop and champion industry standards, and supporting businesses through demonstration of regulatory compliance testing and training accreditation.

Led by the UK Agri-Tech Centre (UKATC), with partners University of Lincoln, Harper Adams University and the Manufacturing Technology Centre (MTC), the consortium is uniquely placed to provide deep agricultural domain expertise and capabilities, as well as broad cross-sectoral robotics knowledge, experience and implementation, spanning national and international regions, farming cultures and practices.

A series of knowledge exchange events are planned to gather input from a diversity of stakeholders across the supply chain. Events will serve to initiate dialog, raise awareness of a regulatory network and inform project direction.

The project team will conduct a comprehensive gap analysis of existing standards and regulations accounting for the unique challenges of agri-robotics, such as operation in uncontrolled outdoor settings with uncertain weather and terrain conditions. Developing a clear understanding of the knowledge gaps is foundational to creating clear and cohesive pathway for users and developers to follow. The output will deliver guidance for industry and regulators and ensure relevant standards and regulations are captured.

Within the testing requirements of agri-robotics the different of levels of autonomy and diverse usage

scenarios will be considered. This includes aligning standards with real-world operational demands to accelerate the commercial adoption of robotic technologies in agriculture.

The team will specify evidence-led training requirements for developers, training providers and end users by gathering information on currently available training and what training is required. To identify training programs for agricultural robotics in the UK and assess the training needed to support its adoption, databases and websites of further education (FE) colleges, higher education (HE) universities, and private training providers were searched for courses related to agri-robotics, agricultural automation, livestock robotics, crop robotics, and autonomous mobile machinery. A cursory search on the UK's Universities and Colleges Admissions Service (UCAS) system identified 343 robotics-related courses, with seven specifically focused on agricultural robotics. These courses cover topics such as robotic automation, autonomous systems, and artificial intelligence, with applications in agricultural systems. Additionally, websites of agri-tech companies providing robotics equipment and solutions were also examined. These companies reveal variable amounts of information on training programs offered.

For further review, the team will deploy two questionnaires. The first, focusing on current training provision, will target any training providers such as agri-colleges, universities, and technology providers to understand current provision on agricultural user training (farmers), and developer training (engineers, technicians, service and maintenance staff). The second questionnaire, focusing on training requirements, will target farming bodies, regulators, manufacturers of machines, and agricultural innovators. The results will highlight the gaps in training and inform the development of relevant training.

Keywords: Agricultural robotics, training, regulation, standards, testing

OP-06. A Robotic Livestock Feed Consumption Monitoring System for Dairy Farm

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Abstract

Accurate monitoring of livestock feed consumption in dairy farms is crucial for milk productivity and animal health. Conventional methods, however, are often time-consuming, labor-intensive, and prone to human error. This study evaluates the accuracy and reliability of a robotic monitoring system, which consists of an attachment mounted on a scheduled moving robot designed to monitor cow feed consumption in real time. The system utilizes optical time-of-flight sensor technologies to track cow feeding variation and estimate feed intake. We conducted field trials on a commercial dairy farm, comparing the performance of the robotic monitoring system with manual measurements and conventional monitoring methods. The results indicate that the robotic monitoring system demonstrates high accuracy and reliability in measuring feed consumption, outperforming conventional methods. Additionally, the system provides actionable insights into cow feeding behavior, enabling farmers to identify opportunities for improvement and optimize their feeding strategies. Our findings demonstrate the potential of robotics and automation to transform livestock management, enhancing efficiency, productivity, and animal welfare. This research contributes to the application of precision agriculture and smart farming technologies, providing a helpful solution for the dairy sector.

Keywords: Robotic, feed monitoring system, dairy farm automation, animal welfare, livestock

OP-07. Physically Realistic Digital Replica of Strawberry Plants for Robotic Harvesting

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Abstract

In agricultural robotics, creating realistic simulation environments is essential for developing and testing computer vision and control algorithms used in tasks like fruit detection, localization, and harvesting. However, most existing digital plant models are designed only for visual purposes and lack the physical properties needed to simulate realistic robot–plant interactions. This limitation is particularly significant for strawberry harvesting, as these plants have complex, flexible structures that are prone to damage, which directly affects the success of automated picking. To address this gap, we introduce a methodology for generating physically accurate, harvestable, randomized strawberry plant models compatible with the Open Dynamics Engine (ODE) and Gazebo (Classic and Sim) within the ROS2 framework. The proposed models simulate dynamic behaviour using a simplified Euler–Bernoulli beam formulation, which approximates plant bending and vibration. These models are discretised into a simulation-ready format, with each plant segment represented as a rigid body, where joint properties define stiffness and damping. Our pipeline enable users to generate randomized yet biologically plausible strawberry plants, incorporating variations in leaf count, stem branching, fruit positioning, and biomechanical characteristics. Preliminary results demonstrate that the simulated plants react predictably to environmental forces, with deformation patterns and fruit detachment behaviour aligning with real-world observations.

Keywords: Strawberry plant, digital twins, robotic harvesting, gazebo simulator, stiffness, damping

OP-08. Development of an IoT-based Smart-Shelf for Real-Time Quality Monitoring of Plant-Based Food

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Abstract

About forty percent of food produced for consumption is wasted during various processing steps, including harvesting, processing, storage, and retail. To maintain food quality and minimize food waste, there is a need for efficient and robust food quality monitoring systems. In the age of digital and advanced sensing technologies, smart sensing systems based on connected multi-sensors can be used for real-time control of various food samples. Increasing consumer demand for plant-based protein-rich food has resulted in the use of various legumes and beans as an alternative source of protein in ready-to-eat food. However, these food samples often have a very short shelf life at the retail displays. Conventional methods for the determination of food quality are often based on visual inspection and solely rely on the best-before date. Therefore, in this research study, a prototype of an intelligent smart-shelf coupled with four sensors (temperature, moisture, pH, and gas) was developed for accurate and real-time sensing of food (plant-based burger patty) quality. This proof-of-concept system was capable of real-time data acquisition and processing. Moreover, the precise locations of "to be spoiled" or "spoiled" food were identified based on sensor readings and fusion into a smart mini-processor, resulting in a tool for better decision making. Developed multivariate models showed the ability to predict and locate the food samples and propose an action for reducing the food waste. Overall, the developed smart-shelf was feasible for future industrial applications and requires validation and further optimization.

Keywords: Smart-shelf, IoT, food, smart sensor, real-time monitoring

OP-9. Behavioral and Structural Profiles of Precision Agriculture Uptake among Italian Winegrowers

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Abstract

Precision Agriculture technologies (PATs) are increasingly being promoted as a means of improving the sustainability and competitiveness of viticulture. However, the adoption of these tools among Italian farmers exhibits significant heterogeneity, influenced by a combination of structural and behavioral factors. Although several studies have investigated these dimensions in isolation, there is limited evidence regarding how they interact to influence farmers' preferences and intentions to adopt specific PATs The present study applies Latent Profile Analysis to assess psycho-behavioral and structural heterogeneity among 272 winegrowers in Italy. Three qualitatively distinct profiles emerged: risk-sensitive sceptics, selective neutrals and usability-oriented high adopters. These profiles exhibit sharply differentiated adoption patterns across technologies. Participation in rural development schemes is the strongest predictor of membership in the higher-propensity profile. In addition, higher educational attainment, male gender and greater average yield are positively associated with this higher-propensity class, while age shows a weak negative correlation. These results inform the design of extension services and policy measures targeted at specific segments. Priority must be given to risk-mitigation trials for cautious growers, targeted information services for select profiles, and integrated PATs bundles for those with a high propensity.

Keywords: Technology adoption, latent profile analysis, risk perception, farmer behavior, segmentation, innovation in agriculture

OP-10. Vegetation Indices Including Soil Confound Plant Health and Canopy Cover: Multi-environment Analysis of Maize Temporal Progression

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Abstract

Vegetation indices (VIs) are valuable phenotypes for estimating crop health and for modeling crop growth temporally. Crop canopies capture sunlight promoting photosynthetic activity, thus contributing to overall biomass and grain yield potential. Plant breeders and agronomists utilize high throughput field data collected by unmanned aerial vehicles (UAVs, also known as UAS or drones) to discover trends in complex traits, such as canopy cover and plant health. VI values are traditionally calculated without removing soil pixels, confounding the separate traits of plant health and canopy cover. Exclusion of soil pixels in calculating VIs (VIns – VIs with no soil) is routinely performed in phenomics and plant breeding to better estimate plant health between varieties, but it fails to account for crop canopy coverage. Here, two models are proposed in which VIns values excluding soil are adjusted for canopy cover using pixel conversions to assess their repeatability and utility compared to traditional VI methods in modeling. The U.S. national maize (Zea mays L.) Genomes-to-Fields (G2F) dataset was used to evaluate the models for 1,210 unique hybrids across 19 environments with 343 total flights. Heritability (repeatability) was used as an objective measure to compare VI estimates across different models. Results indicate that the modeling techniques are environment- and VI-dependent, with canopy-adjusted models outperforming traditional methods for specific subsets of the data. However, estimating these separately increased the repeatability by over 15% in some cases. Best linear unbiased predictors (BLUPs) for VIs are commonly used to track growth patterns, but they treat each flight date as discrete timepoints, limiting insights into growth trajectories and making it difficult to develop predictive scenarios for breeding purposes. Canopy cover progresses directionally while plant health varies across time, but both differ across environments and have sparse and unaligned measurable timepoints. This requires techniques that can handle complex, limited temporal data. Functional principal component analysis (FPCA) and long short-term memory (LSTM) were utilized as alternative methods to handle missing flight information across environments, and to enhance biological understanding of canopy and plant health. Understanding the patterns of canopy cover and plant health progression in maize will unlock insights on the optimal strategies for efficient accumulation of photosynthetic inputs/outputs under diverse environments.

Keywords: Crop growth modeling, unmanned aerial vehicles, vegetation indices, plant breeding, functional principal component analysis, long short-term memory, deep learning

OP-11. Development of Large-Scale Machine Vision System and Synchronization with Optimized Nozzle Control for Spot Application on Colorado Potato Beetle

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Abstract

This study investigates the development and deployment of multiple machine vision systems and synchronizing them on a wide boom sprayer. Each machine vision system includes a pipeline, leveraging YOLOv5 to enable real-time detection of beetles for spot spraying applications. 30 RGB cameras were mounted on the sprayers boom. The machine vision pipeline was developed in two primary phases: training and testing. During the training phase, images of beetles were collected to create a dataset comprising 328 training, 41 validation, and 42 testing images. Next, an electronic control unit (ECU) to synchronize multiple machine vision systems with nozzles was developed. To consolidate detection data from all cameras into a single processing unit compatible with the ISOBUS protocol. The ECU receives protocol messages containing detection information. Field tests confirmed the performance and reliability of the system. Evaluations involved a Case IH Patriot 3240 sprayer with 60 individually controlled nozzles and a custom sprayer mounted on a tractor with 27 nozzles. Experiments simulated various target distribution patterns, including individual targets, intersections, and bulk distributions. The ECU dynamically adjusted nozzle opening times based on vehicle speeds of 3.22 km/h, 6.44 km/h, and 9.66 km/h, maintaining consistent spray lengths of 71.52 cm across all scenarios. This standardized ECU enables the seamless synchronization of multiple machine vision systems with nozzles on wide boom sprayers, facilitating precision spot spraying with enhanced efficiency and reduced environmental impact.

Keywords: Machine vision, deep learning, spot application, control area network

OP-12. Hyperspectral Band-Selection for Vegetation Health Monitoring Using Explainable Models

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Abstract

Health monitoring of vegetation can be achieved using hyperspectral cameras and spectrometers. However, both types of equipment are expensive, and in the case of spectrometers, the data collection process is time- and resource-intensive. Although the information provided by these instruments is comprehensive, it is often redundant for specific tasks-only a portion of the spectral bands typically offers useful information for applications such as leaf water content prediction.
In this context, we propose identifying the most important bands or sets of bands for leaf water content prediction. To this end, we use one-dimensional convolutional neural networks (1D-CNNs) to predict leaf water content using input data that includes all spectral bands from 350 to 2500 nm. We then apply the Grad-CAM algorithm to identify the bands most relevant to the prediction task. The dataset comprises spectral signatures of avocado, olive, and grape leaves within the 350–2500 nm range, captured at various stages of dehydration. To assess the utility of the identified bands, we train additional 1D-CNNs to estimate vegetation indices associated with other physiological traits.
Through this methodology, we identify three key spectral regions that contribute most to leaf water content detection: 550–688 nm, 1886–2180 nm, and 2260–2500 nm. Furthermore, using only these regions as inputs, we successfully predict additional vegetation indices, namely, the Leaf Water Index (LWI), the Shortwave Infrared Water Stress Index (SIWSI), and the Transformed Chlorophyll Absorption in Reflectance Index (TCARI). achieving correlation coefficients of up to 0.94 in some cases within the testing dataset.

Keywords: Plant health monitoring, vegetation indices, explainable AI, deep learning

OP-13. Mapping the Spatial Evolution of Drift-Prone Droplets from Agricultural Nozzles under Wind Tunnel Conditions

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Abstract

This study addresses a key challenge in agriculture: spray drift, which causes environmental contamination and economic loss. The research aims to understand drift better by investigating how droplet size distribution (DSD) evolves spatially from different agricultural nozzles under controlled wind conditions. It specifically seeks to understand how nozzle type and wind speed influence droplet dispersion and to identify specific droplet sizes that are susceptible to drift.

Experiments were conducted in a wind tunnel using three commercial nozzles (two flat-fan and one hollow-cone) at wind speeds of 1, 3, and 5 $m \cdot s^{-1}$. A laser diffraction system was used to measure DSDs at various downstream and vertical locations, capturing both airborne and deposited droplets. The results showed that both nozzle type and wind velocity significantly affect DSDs and dispersion. Droplets below a certain critical diameter were highly susceptible to drift. A notable finding was the self-similar behavior of DSDs when normalized by the volume-weighted mean diameter (D43), suggesting that the entire distribution can be predicted from a single parameter.

This work provides a valuable experimental and modeling framework for analyzing spray drift. The findings can help optimize nozzle selection to have effective chemical delivery.

Keywords: Agricultural nozzle, aerosol, droplet size distribution, spray drift, wind tunnel

OP-14. Automation of Section Control of Agricultural Sprayer with AgOpenGPS Platform

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Abstract

Precision farming reduces chemical use and improves profitability. The autosteering and automated section controls help the driver focus on the driving task, such as observing obstacles. The open-source system AgOpenGPS offers a cost-effective and customizable alternative to commercial section control solutions and autosteering.

The aim of this study was to develop a control box for a Hardi sprayer, operated via the AgOpenGPS software. The goal was to automate section control, prevent overlapping spraying, and assist in route mapping. The first prototype was a controller box placed on top of Hardi's display. The next prototype was based on relay boards and controlled with a Teensy microcontroller. The system was connected to AgOpenGPS through a USB interface. Testing was carried out both in simulation and in practical field trials, focusing on reliability. The first prototype of relay box proved unreliable due to wiring issues. The second version was simplified, resulting in improved wiring reliability.

Field tests showed that the control box responded quickly to section boundaries and significantly reduced overlapping spraying. An open-source AgOpenGPS-based control box offers a flexible and affordable option for sprayer automation. However, it requires technical skills and personal time investment. Building such a system also benefits from having a network of people to consult for advice.

Keywords: AgOpenGPS, precision farming, sprayer, section controller

OP-15. Deep Eutectic Solvent Pre-treatment of Common Reed – A Techno-Economic and Environmental Assessment

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Abstract

Deep eutectic solvents (DES) are proposed as promising alternatives to conventional solvents for the extraction of value-added products and as pre-treatment agents in biomass processing, particularly in the valorisation of lignocellulosic materials. They were widely regarded as cost-effective, safer, and more environmentally benign options compared to traditional solvents. While numerous studies demonstrated the applicability of DES at laboratory scale – either for value-added compound extraction or for enhancing biogas production through biomass pre-treatment – few studies addressed the technological scalability, economic viability, and environmental impacts of such processes.

This study investigated a holistic biorefinery concept based on published laboratory data, focusing on the integrated utilization of lignocellulosic biomass (Phragmites australis, or common reed) pre-treated with a DES composed of choline chloride and formic acid. The process aimed to recover phenolic compounds from the liquid phase and to generate biomethane and compost from the solid residue following pre-treatment.

The methodological framework included a conceptual process scale-up, with plant layout development, mass and carbon balance calculations, and comprehensive economic and environmental assessments. Preliminary results showed that the process was technically scalable. However, the downstream separation and purification of phenolic compounds required considerable effort and further processing steps to obtain a market-ready product.

The energetic analysis indicated that thermal energy demand, mainly in the form of steam, constituted the largest share of total energy consumption. This was primarily due to the evaporation required for (a) separating rinsing water and DES for recycling both streams and (b) regenerating ethanol used in the desorption of phenolic compounds. The mass balance revealed that the flow of auxiliary materials (DES, water, ethanol) was substantial in comparison to the relatively low yield of the main value-added product, phenolic compounds. Despite internal recycling loops, the net consumption of auxiliaries remained high.

Carbon balance assessment shows that ca. 40 % of the input carbon was retained in the product streams. However, a substantial portion of the carbon, mainly in the form of solubilized sugars from hemicellulose, remained unseparated from the DES and thus unutilized. Closing this carbon gap is crucial, as the current carbon efficiency is lower than that of conventional anaerobic digestion processes.

The economic assessment revealed that operational expenditures (OPEX) dominated overall costs, driven largely by the consumption of choline chloride and formic acid. Revenues from by-products were insufficient to compensate for these costs, resulting in a calculated minimum selling price (MSP) of ca. 65 € kg^{-1} for phenolic compounds. This could be competitive in high-value markets; however, it should be noted that additional purification steps would be required to isolate individual components for targeted applications. The sensitivity analysis further demonstrated that process viability was heavily influenced by the prices of choline chloride, formic acid, and steam for the provision of thermal energy, while capital expenditures (CAPEX) played a minor role.

The environmental analysis showed that auxiliary and energy consumption had significant implications for environmental performance. A major share of climate-relevant emissions was linked to the production and supply of chemicals used in pre-treatment, with choline chloride being the primary contributor.

In conclusion, while the process demonstrated technical feasibility and potential for economic realization, several critical challenges were identified. Improving the carbon balance by recovering currently unutilized fractions is essential for achieving higher carbon efficiency, potentially through a multi-product biorefinery approach. Additionally, optimizing and reducing auxiliary flows is necessary, as current consumption levels are disproportionate to the product output. Finally, a more thorough environmental evaluation is needed to ensure the environmental sustainability of the overall process.

Keywords: Techo-economic assessment, environmental assessment, deep eutectic solvents, biomass pre-treatment

OP-16. Wind Tunnel-Based Agricultural Spray Nozzles Performance Prediction

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Abstract

Spray drift presents a challenge in agricultural applications, diminishing both the efficiency of pesticide delivery and environmental safety. This study introduces an index which is reference-free metric that quantifies the airborne fraction of spray resulting from different nozzle designs in a wind tunnel. The assessment was conducted on four nozzle types, at various operation heights (0.8, 1.0, and 1.2 m) and wind speeds (1, 3, and 5 m s^{-1}). Advanced measurement approaches, including laser diffraction within the breakup zone and high-speed shadowgraphy, provided detailed profiles of droplet size distributions, spray plume behavior, and deposition characteristics. These diagnostics uncovered distinct differences between nozzles in droplet generation, initial momentum, and vulnerability to drift. The DPI was calculated for each axial distance, delivering a consistent basis for ranking nozzle performance. A significant advancement of this research was the formulation of predictive correlation, utilizing nondimensional factors such as momentum flux ratio, normalized droplet diameter, and downstream distance. The DPI framework can assist nozzle manufacturers, spray operators, and regulatory authorities in making informed decisions to enhance application effectiveness and lower the likelihood of off-target impacts.

Keywords: Nozzle selection, spray drift, wind tunnel, pesticide application

OP-17. Megaweeds: an Experimental Study on Weed Detection with YOLOv7 using a Novel Dataset

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Abstract

Modern agriculture must address growing food demand, labor shortages, and environmental concerns. Precision agriculture (PA), which involves crop monitoring and automation, offers solutions. A key element of PA is crop and weed detection, often achieved with deep learning. This study applies YOLOv7, an object detection model, to this task. While most approaches pre-train YOLOv7 on the general COCO dataset, COCO lacks plant images. To address this, we built the MegaWeeds (MW) dataset by combining seven existing datasets, totaling 19,317 images of crops and weeds, to provide domain-specific pretraining. Performance was tested using the Lincolnbeet dataset of sugar beets and weeds, comparing models pre-trained on COCO and MW. Results showed similar mean average precision scores, i.e. 78.7% (COCO pretrained) and 78.6% (MW pretrained). Nonetheless, pretraining with MW proved advantageous by enabling faster convergence and better zero-shot detection than COCO. The study surpassed earlier YOLOv7 results on the same dataset and demonstrated that domain-specific pretraining shortens transfer learning and enhances detection efficiency.

Keywords: Precision agriculture, weed detection, crop detection, YOLOv7, deep learning

OP-18. Driving Sustainability: A Life Cycle Emissions Analysis of Multi-Purpose Tractors in Turkey

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Abstract

As agriculture moves toward more sustainable practices, understanding the environmental impacts of agricultural machinery has become increasingly important. This study presents a comprehensive life cycle assessment (LCA) of a tractor, aiming to evaluate its GHG emissions from production to end-of-life of a multi purpose tractor in Turkey. The functional unit and boundaries are determined firstly. For the products that are the subject of this LCA study, the functional unit has been chosen as 1 product of final product. All the resulting environmental impacts were analysed as impacts per 1 kg vehicle. year of these final products produced. The system boundary of this study is from cradle to grave. Tractor lifecycle includes raw material, manufacturing, use and end of life cycle phases mainly. Service life is considered as 10 years. The life cycle assessment (LCA) is performed by combining primary, secondary and LCA software database data according to the standards ISO 14040 and ISO 14044. IPCC 2021 method is used. %68 of the emissions originates from Use Phase, %18 from raw material and part production phase, %11 from maintenance, %2 from End-of-life (EOL), %1 from tractor production.

Keywords: GHG emissions, life cycle assessment, tractor

OP-19. Valorization of Olive Tree Pruning Waste via Different Pretreatment Strategies: Unlocking Valuable Compounds for Integrated Biorefinery Applications

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Abstract

The olive oil industry is a major global agricultural sector, generating large amounts of olive tree pruning waste (OTPW) as a by-product of annual pruning practices. This residue, averaging 3 tons per hectare, is often burned or left in the field, leading to environmental concerns. Valorization of OTPW through biorefinery approaches offers opportunities for producing biofuels and high-value bioproducts. In this study, OTPW was subjected to four pretreatment methods: (i) deep eutectic solvent (DES; choline chloride:formic acid, 1:2 molar ratio), (ii) dilute acid (2.5% H_2SO_4), (iii) alkaline (2.5% NaOH), and (iv) autohydrolysis. DES, acid, and alkaline pretreatments were conducted at 90–130 °C for 20–60 min, while autohydrolysis was performed at 150–190 °C for 10–30 min. Solid recovery varied between 87% and 41%, decreasing with severity except in alkaline pretreatment. Among the tested methods, DES pretreatment achieved the highest total phenolic content (144.5 mg GAE/g dry biomass), highlighting its efficiency for phenolic extraction. Acid pretreatment yielded the highest monosaccharide concentrations (11 g/L xylose, 7.5 g/L glucose), making it suitable for fermentable sugar production. Autohydrolysis was the most effective for xylo-oligosaccharide (XOS) generation, achieving up to 11.3 g/100 g biomass at 190 °C for 10 min, underscoring its potential for prebiotic applications. The results demonstrate that pretreatment type strongly influences the selective recovery of valuable compounds. These findings emphasize the role of tai-lored pretreatment strategies in enabling integrated biorefinery concepts, supporting the sustainable valorization of OTPW for biofuels, functional ingredients, and bioactive compounds.

Keywords: Olive tree pruning waste, lignocellulosic biomass, pretreatment, extraction, phenolics, monosaccharides, oligosaccharides

OP-20. Assessment of Olive Tree – Legume Crops Intercropping with Respect to Agronomic Traits and Economic Impact in Mediterranean Climate Conditions

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Abstract

Türkiye is the fifth-largest olive (*Olea europaea* L.) producer, accounting for 8.6% of global olive cultivation, with 10.3 million hectares dedicated to olive groves worldwide. Olive tree with annual crop intercropping therefore represents a promising approach for sustainable land use and income diversification, especially in Mediterranean agroecosystems. This research assessed the economic feasibility of intercropping chickpea (*Cicer arietinum* L.), lentil (Lens culinaris Medik.), and peanut (Arachis hypogaea L.) with olive orchards in Antalya, which has a coastline in the Mediterranean Sea. Among the intercrops studied, chickpea was the most economically feasible. Lentil had little profitability with a 4.1% return in 2024. In contrast, peanut cultivation incurred a net loss primarily due to high production costs and reduced yields resulting from competition for resources. Chickpea's exceptional performance—transforming about 45% of gross income into profit while sustaining olive productivity—establishes it as the ideal intercrop for Mediterranean climate areas. Moreover, chickpea production increases soil nitrogen levels through biological fixation, thereby enhancing overall orchard fertility. These findings underscore chickpea–olive intercropping as a viable and sustainable intensification strategy that can improve farm profitability and ecological resilience in Türkiye's olive-growing regions. The study provides valuable insights for policymakers and farmers aiming to enhance land-use efficiency and economic returns in perennial orchard systems.

Keywords: Chickpea, intercropping, Mediterranean climate, olive orchards, soil fertility

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OP-21. High-Resolution Leaf Tracking for Real-World Crop Phenotyping: Introducing CanolaTrack and LeafTrackNet

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Abstract

Tracking the life of every single leaf open new ways in crop phenotyping by revealing fine-grained plant growth patterns and early stress signals, that are not visible at coarser scales. However, the full potential of accurate leaf tracking over time remains largely unexplored due to the absence of robust tracking methods—particularly for structurally complex crops such as canola. Existing plant-specific tracking methods are typically limited to small-scale species or rely on constrained imaging conditions. In contrast, generic multi-object tracking (MOT) methods are not designed for dynamic biological scenes. Progress in the development of accurate leaf tracking models has also been hindered by a lack of large-scale datasets captured under realistic conditions. In this work, we present **CanolaTrack**, a new top-down RGB benchmark dataset comprising 5,704 images and 31,840 annotated leaf instances spanning the early growth of 184 canola plants. To enable accurate leaf tracking over time, we introduce **LeafTrackNet**, an efficient framework that combines a YOLOv10 leaf detector with a MobileNetV3-based embedding network, linked over time via an embedding memory association strategy.

We evaluate the performance of our proposed LeafTrackNet method on CanolaTrack using standard MOT metrics (HOTA, Det, AssA, IDF1, MOTA) and benchmark against both plant-specific and generic MOT baselines (LeTra, DeepSORT, ByteTrack, BoT-SORT, MOTRv2). LeafTrackNet outperforms all competitors across all five metrics, with gains over the strongest baseline of 11.22% HOTA, 0.48% DetA, 5.33% AssA, 10.60% MOTA, and 10.01% IDF1. With our work we provide a new standard for leaf-level tracking under realistic conditions and we provide CanolaTrack - the largest dataset for leaf-tracking in agriculture crops, which will contribute to future research in plant phenotyping. Code and dataset will be released publicly.

Keywords: Canola, deep learning, multi-object tracking, plant phenotyping, RGB image

OP-22. Using Deep Learning to Detect Pea Root Nodules within a Complex Soil Media Background

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Abstract

Root nodule phenotyping is essential for understanding biological nitrogen fixation in legumes, an important process for crop growth and productivity; however, traditional manual approaches for analyzing root nodules can be slow and prone to human bias, making them impractical for large-scale studies. More recent studies have utilized deep learning for high-throughput nodule assessments but usually focus on images of isolated roots. In this study, we implemented and evaluated two state-of-the-art deep learning architectures (YOLOv12 and Mask R-CNN) to automate the detection of root nodules from pea root systems grown within a controlled rhizobox environment. To generate ground truth data, we annotated 62 high-resolution images of root systems, growing within sand-peat media mix.

The study also incorporated two complementary Explainable AI (XAI) techniques: Gradient-weighted Class Activation Mapping++ (Grad-CAM++) for class-discriminative explanation and Feature Activation Maps for low-level attention visualization.

A comparative evaluation of YOLOv12 and Mask R-CNN architecture shows increased nodule detection performance with YOLOv12 (precision: 59%, recall: 71%) as compared to Mask R-CNN (precision: 46%, recall: 60%), with comparable Intersection over Union (IoU) values (0.61 vs. 0.67). Our implementation of explainable AI techniques through Grad-CAM++ and feature activation visualizations help explain the performance differences observed between the two architectures.

Keywords: Object detection, explainable AI (XAI), deep learning, rhizobium root nodule, YOLO, Mask R-CNN, rhizobox

OP-23. Exploring the Geocooling Potential of Agricultural Greenhouses in Desert Climates: The Case of Southern Morocco

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Abstract

Agricultural greenhouses play a crucial role in meeting the growing demand for crop production. They have become so essential that they are even found in extreme climatic conditions, particularly in desert environments. These regions are characterized by high temperatures, which significantly impact crop growth. Consequently, microclimate management has become crucial for maintaining optimal conditions for greenhouse plant development. Analysis of meteorological data for desert areas reveals that cooling degree-days often exceed heating degree-days. This explains why farmers in these regions use adapted technologies such as ventilation, fogging, evaporative cooling etc. The aim of the present study is to explore the potential of geocooling for greenhouses in southern Morocco. To this end, a combined numerical and experimental approach was adopted to assess its effectiveness in a greenhouse installed in Foum El Oued region (Laayoune, Morocco). A mathematical model of physical phenomena influencing the greenhouse climate, including interactions with the soil and plants, turbulent convective transfers, infiltration, condensation etc. was developed. A numerical approach based on computational fluid dynamics (CFD) was used to predict the thermal behavior of the greenhouse, both with and without geocooling. Prior to interpreting the simulation results, an analytical and experimental validation of the model was carried out, comparing its output with literature data. This model was then used to size the geocooling system envisaged, in particular the nominal air flow rate of the fan, its energy consumption, and other parameters. Afterwards, an experimental study will be conducted on the geocooling system to confirm its effectiveness in the desert environment of Foum El Oued.

Keywords: Agricultural greenhouse, arid climate, cooling technologies, earth-to-air-thermal-exchanger, plant production, CFD analysis, thermal stress

OP-24. Hazelnut (*Corylus avellana* L.) Mass Prediction using Machine Learning Models Based on Physical Attributes

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Abstract

Türkiye is the world's leading hazelnut producer, supplying ~70% of global demand. Efficient processing and shelf-life management depend strongly on nut quality, for which mass is a key determinant throughout postharvest handling. This study investigates non-destructive prediction of shelled hazelnut mass from easily measurable physical attributes (size and shape) using machine learning. Seven cultivars (Çakıldak, Kalınkara, Palaz, Sivri, Tombul, Yerli, Yomra) were collected from orchards in the Black Sea region and stored at 5 ± 0.5 °C for three weeks. For each cultivar, 150 samples were evaluated. Mass was measured with an electronic balance (±0.001 g), and length, width, and thickness with a digital caliper (±0.01 mm). Derived traits-volume, geometric mean diameter, projected area, surface area, sphericity, shape index, aspect ratio, and elongation-were computed via standard equations. Pearson correlation was used to explore relationships among predictors. Three models-automated linear regression, Random Forest regressor, and an artificial neural network-were trained to estimate mass for both nuts and kernels. The best performance was achieved by Random Forest (up to ~86% accuracy), followed by automated linear regression (~83.8%), indicating strong potential for rapid, non-destructive mass estimation. These findings provide a practical baseline for developing more advanced predictive systems; integrating chemical attributes with physical features may further improve cultivar discrimination and prediction accuracy, thereby enhancing efficiency in postharvest hazelnut handling.

Keywords: Hazelnut, mass prediction, machine learning, Random Forest, non-destructive measurement, physical attributes

OP-25. Classification of Hazelnut Cultivars Using Attention-Enhanced Deep Learning Models

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Abstract

The classification of hazelnut cultivars lies at the heart of quality control and processing, where subtle visual differences between cultivars affect the classification process. Whilst the evident potential of deep learning models, particularly convolutional neural networks (CNNs), in automating this process, the integration of attention mechanisms in this domain remains unexplored. Henceforth, the PICO model (Problem, Intervention, Comparison, Outcomes) was used to formulate an evidence-based research question: "*In hazelnut cultivar classification, does the use of an attention-enhanced deep learning model, compared to traditional CNN-based models, improve classification accuracy and efficiency?" T*herefore, this study aims to investigate the impact of attention mechanisms on hazelnut cultivar classification by integrating the Convolutional Block Attention Module (CBAM) into a CNN framework, which has proven to enhance feature focus in other fields. The study developed and evaluated an attention-enhanced model built on a ResNet-50 backbone. For a more robust and comprehensive model, seven hazelnut cultivars, i.e., Tombul, Çakıldak, Foşa, Kara Findik, Kargalak, Falaz, and Cancava, collected in, Turkiye were studied. A controlled image acquisition set-up using a high-resolution camera and a black background was used to capture 150 images for each cultivar, producing a dataset of ~3,500 images. After this, the captured images were pre-processed for quality enhancement and improved model training performance. The developed model was compared against a traditional ResNet-50 baseline model using accuracy, F1-score, and inference time metrics. By exploring the potential of attention-based deep learning models in hazelnut classification, the study promises a scalable and more efficient approach not only for industrial hazelnut handling but for the entire domain of food handling and processing.

Keywords: Hazelnut cultivars, classification, attention-mechanisms, deep learning

OP-26. MobileNetV2-Driven Image Recognition for Discriminating Pistachio Varieties: Akuri, Antep, Halebi, Kırmızı, and Tekin

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Abstract

Pistachios are one of the most economically valuable nut crops, with different varieties exhibiting distinct morphological characteristics, quality attributes, and market values. Accurate classification of pistachio cultivars is essential for quality control, authentication, and post-harvest handling in the agricultural supply chain. Traditional methods of identifying pistachio types rely heavily on manual inspection, which is time-consuming, prone to human error, and inefficient for large-scale processing. In this study, we propose an automated and efficient approach for pistachio variety classification using a deep learning model based on the MobileNetV2 architecture. The main objective is to develop a lightweight convolutional neural network (CNN) capable of distinguishing between five common pistachio types Akuri, Antep, Halebi, Kırmızı, and Tekin with high accuracy and minimal computational cost. To achieve this, a dataset consisting of labeled images of the five pistachio types was collected and preprocessed using standard augmentation techniques to enhance variability and improve generalization. Transfer learning was employed by fine-tuning the MobileNetV2 model, pretrained on ImageNet, to adapt it for the specific classification task. The model training process was carefully monitored using early stopping and validation accuracy to prevent overfitting. Experimental results demonstrated the effectiveness of the proposed approach, with the model achieving 93% training accuracy, 95% validation accuracy, and 94% test accuracy. These results indicate strong classification performance and generalizability across unseen data. The findings suggest that MobileNetV2 can serve as a practical and scalable solution for real-world pistachio classification tasks in both industrial and research settings. This study contributes to the growing body of work on AI-driven agricultural applications and highlights the potential of deep learning for improving the efficiency and reliability of crop identification and quality assurance systems.

Keywords: Pistachio classification, MobileNetV2, deep learning, convolutional neural networks (CNN), transfer learning

OP-27. Deploying MobileNetV2 on Edge Impulse for Hazelnut Quality Inspection

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Abstract

Hazelnuts are a valuable agricultural product with significant economic and nutritional importance, particularly in countries like Turkey, which leads global production. Ensuring the quality of hazelnuts during post-harvest processing is essential to maintain market standards and consumer satisfaction. Traditional inspection methods are often labor-intensive, inconsistent, and inefficient, highlighting the need for automated and intelligent systems. In this study, we propose a lightweight deep learning model implemented on the Edge Impulse platform to classify hazelnuts into three categories: Hole, Crack, and Good Quality. The dataset was labeled using the Edge Impulse image annotation tool and divided into training (81%) and testing (19%) subsets. The MobileNetV2 0.35 model was employed through transfer learning, achieving a validation accuracy of 97.2% and a test accuracy of 93.36%. The model demonstrated efficient real-time performance with a processing speed of 827 milliseconds per image and low peak RAM usage of 119.4 KB, making it highly suitable for deployment on edge devices in industrial settings. Compared to previous studies that relied on complex or resource-heavy architectures, our model balances high accuracy with minimal computational requirements. The findings validate the potential of lightweight deep learning models in automating hazelnut quality assessment and offer a scalable solution for small and medium-sized processing facilities. This study represents a step toward smart agriculture through embedded AI-driven quality control.

Keywords: Smart Agriculture, embedded systems, defect detection, lightweight models, hazelnut classification

OP-28. Potential for Pre-Harvest Prediction of Tuber Potato Physiological Disorders

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Abstract

Climate change is leading to warmer, drier summers in crop-producing regions of the UK and Northern Europe. Periods of drought and water stress during crop growth are associated with potato tuber physiological disorders. The physiological mechanisms behind these stress-induced disorders are not well understood, but sensing techniques show promise in identifying early signs of water stress that may lead to disorders, enabling timely intervention. This study compares two sensing techniques for detecting drought stress with standard physiological methods for measuring water status in potatoes and investigates the relationship between sensing data and drought-induced tuber physiological disorders. The null hypothesis is that there is no significant difference between traditional and sensing-based phenotyping methods in detecting drought stress leading to tuber physiological disorders. A 2024 polytunnel pot trial was conducted with four varieties demonstrating different levels of susceptibility to drought: Markies (control), Russet Burbank, Challenge (both moderate susceptibility) and Nectar (susceptible) - exposed to 30% of field capacity. The drought stress was applied at tuber initiation for 25 days. Measurements were taken at three different times: 7 days after stress (DAS), 14 DAS, and 21 DAS. Relative leaf water content (RWC), stomatal conductance (SC) were the physiological parameters of crop water status evaluated. Two sensing techniques were employed: thermal imaging to examine leaf temperature, and chlorophyll fluorescence to detect specific fluorescence ratios (Fv/Fm). At the end of the trial, yield parameters were quantified, and physiological disorders were assessed using standard commercial scoring systems. Preliminary observations show a strong correlation between leaf temperature and both SC and RWC. Among all measured traits, leaf temperature showed the highest predictive power for netting. These findings suggest the potential for leaf temperature as a non-invasive, high-throughput phenotyping method for assessing drought stress in potatoes.

Keywords: Potato, phenotyping, sensing technology, tuber physiological disorders, water stress

OP-29. A Novel Agricultural Spraying Aerial Robot (AgRoHedral): Performance Improvement in the Presence of Sloshing Effect

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Abstract

Aerial spraying with robots has attracted the attention of farmers in recent years. This study introduces "AgRoHedral", an innovative design for agricultural spraying aerial robots. This configuration integrates four servo motors to control the angles of four propeller axes, thereby overcoming the limitations of conventional under-actuated multi-rotors. A detailed mathematical model is developed for this system. The sloshing of fluid inside the container is modeled as the vibration of a variable-mass pendulum, connected by a spherical joint with viscous friction. To align the conditions for comparison between the AgRoHedral and conventional sprayers, controllers are designed based on sliding mode control. Factors are defined to have a precise comparison between AgRoHedral and a conventional spraying quadrotor in energy usage, sloshing and performance. AgRoHedral exhibited superior transient and steadystate behaviors, particularly in sloshing behavior, due to its ability to move without rotating its body and its enhanced actuation system. This was achieved without an increase in power usage compared to conventional spraying multi-rotors. Also, the omni-directional spraying is introduced and discussed as another capability of the AgRoHedral, solving many challenges in spraying trees. This research aligns with project SAC-1, one of the objectives of our laboratory, *Sharif AgRoLab*.

Keywords: Tilt rotor, hedral fluid oscillation, nonlinear robust control,·sliding mode control, fully-actuated quadrotor

OP-30. End-of-Line Traceability of Dried Jujube: Classifying Microwave Power Levels and Ultrasound Pretreatment with CNNs

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Abstract

Verifying the exact drying route (microwave power level and whether ultrasound (US) pretreatment was applied) in finished jujube (*Ziziphus jujuba*) products is essential for traceability and quality assurance; however, this process is typically labor-intensive and operator-dependent. This work reframes end-of-line process verification as a visual, multi-factor classification problem and evaluates deep learning models for discriminating eight drying combinations (100, 200, 300, 600 W; with/without US). A balanced dataset of 1,760 images (220 per class) of dried jujube slices acquired under controlled imaging was preprocessed to 224×224 px and modeled with four transfer-learning CNNs (ResNet-18, DenseNet-121, ConvNeXt-Tiny, ConvNeXt-Base) in the Fastai/PyTorch stack. Performance was assessed using accuracy, precision, recall, F1-score, and AUC. A Flask-based REST API was implemented for real-time inference with CPU-optimized settings (model.eval, torch.no_grad) to facilitate practical deployment. DenseNet-121 achieved the highest overall accuracy (~99%) with consistently high precision/recall across classes; confusion-matrix and ROC/AUC analyses confirmed robust separation among the eight drying classes, including US-assisted conditions. The proposed pipeline enables rapid, non-destructive discrimination of multi-factor drying conditions in jujube, thereby advancing traceability and quality control with a lightweight model and a standardized imaging protocol suitable for near-real-time use. The approach enables end-of-line verification without additional chemical assays and is readily extensible to other products and drying recipes.

Keywords: Jujube, deep learning, quality assurance, traceability, computer vision

OP-31. Optimization and Performance of an Artificial Intelligence-Based Greenhouse Dryer

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Abstract

The drying characteristics of eggplant samples with different slice thicknesses (5,10,15,20,25 and 30 mm) were investigated using a hybrid greenhouse solar drying system. Eggplant samples with an average initial moisture content of about 12.24 kg water/kg dry matter were dried to a final moisture content ranging from 0.09 to 0.11 kg water/kg dry matter. In the study, drying characteristics such as moisture content (MR), moisture content (MC) and drying rate (DR) were estimated using greenhouse temperature, greenhouse relative humidity, outdoor temperature, outdoor relative humidity, wind speed and solar radiation as inputs. While evaluating the drying characteristics, eggplants were considered separately according to their thickness. Machine learning algorithms such as multilayer perceptron (MLP), k-Nearest Neighbor (k-NN), Random Forest (RF), Gaussian Process (GP) and Support Vector Regression (SVR) were used for modeling. The performance of the models was evaluated using different test metrics such as coefficient of determination (R), mean absolute error (MAE), root mean square error (RMSE), root absolute error (RAE) and root relative square error (RRSE). These five machine learning algorithms successfully predicted the drying process. For eggplant samples, the RF algorithm performed best in predicting moisture content (R=0.9992), moisture content (R=0.9980) and drying rate (R=0.9966), followed by the SVR algorithm. Artificial intelligence and machine learning approaches can be efficiently used for predicting drying characteristics and hybrid greenhouse solar drying. It proves that RF algorithm is a good alternative to artificial neural network (ANN).

Keywords: AI, drying characteristics, machine learning, trial criteria, hybrid greenhouse drying

OP-32. Response of Soybean Forage Yield and Quality to Varying Irrigation Levels

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Abstract

This study evaluated the effects of different irrigation levels on the forage quality parameters of soybean (*Glycine max* L.). Acid detergent fiber (ADF) and neutral detergent fiber (NDF) values were lower under reduced irrigation (I25: 29.15% and 35.45%, respectively), but gradually increased with higher irrigation, reaching their maximum at I100 (ADF: 32.20%; NDF: 38.67%). Similarly, acid detergent lignin (ADL) content showed an increasing trend with irrigation. Ash content (ASH) increased markedly with irrigation, recording the highest value at I100 (13.81%). In contrast, crude protein (CP) concentration was highest under deficit irrigation (I25: 24.52%) and lowest under full irrigation (I100: 20.84%). These results indicate that while higher irrigation levels may favor biomass production, they can negatively affect forage nutritive value, particularly crude protein content. Overall, deficit irrigation (I25–I50) resulted in higher protein concentrations, whereas full irrigation (I100) increased fiber fractions, which may reduce forage digestibility. Therefore, irrigation strategies play a crucial role in determining the feeding value of soybean forage.

Keywords: Deficit irrigation, soybean forage, crude protein, fiber fractions (ADF, NDF, ADL), forage digestibility

OP-33. Design and Preliminary Evaluation of an Integrated Nondestructive Grain Moisture Sensing System for Digital Agriculture

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Abstract

Accurate, rapid, and nondestructive determination of grain moisture underpins fair pricing, storage management, and quality control, yet many commercial instruments remain costly, calibration-limited, or difficult to adapt across crops and seasons. Rapid, nondestructive, and reliable moisture determination is central to pricing, storage, and quality control of grains, yet many commercial instruments are costly, calibration-specific, and hard to update across crops and seasons. We present an integrated platform that combines compact microwave sensing with an IoT-enabled data backbone and machine learning. The RF front-end implements a free-space measurement unit operating in the 2-4 GHz band, acquiring amplitude–phase responses and deriving dielectric features (ε', ε", tan δ, attenuation, phase shift) via on-device vector processing. A microcontroller coordinates frequency synthesis and synchronous acquisition, while the PCB layout with embedded couplers enhances repeatability by minimizing connector variability. To support scalable deployment, the device streams data to a cloud stack comprising an MQTT broker, web/API services, and a relational database for secure storage, audit, and visualization. The backend enables remote configuration, user management, and export utilities, and links to analytics modules for model training and post-processing. Two complementary calibration pathways are explored: transmission-based features from S_{21} and resonance-based indicators (frequency shift, -3 dB bandwidth). These feed regressors such as k-nearest neighbors, random forest, and multilayer perceptron to estimate moisture content and, inversely, bulk density. Performance is assessed with correlation (R), RMSE, and MAE under static and dynamic conditions. Benchtop trials demonstrate end-to-end functionality—embedded acquisition, on-device processing, secure telemetry, cloud analytics, and user feedback. By decoupling hardware from calibration via cloud-maintained libraries that can expand each harvest, the platform targets portable, lower-cost, and updateable moisture sensing suited to in-situ monitoring. This integration of microwave sensing, IoT telemetry, and data-driven modeling offers a practical route to faster measurements, improved traceability, and more robust decisions in digital agriculture.

Keywords: Microwave sensing, grain moisture, bulk density, IoT-enabled platform, machine learning, cloud-based calibration

OP-34. Water Stress Impacts on Soybean Growth, Yield, and Water Use Efficiency in Semi-Arid Regions

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Abstract

Climate change and increasing water scarcity have made efficient water use essential for sustainable agricultural production. This study was conducted in 2024 under the semi-arid conditions of Kayseri Province, Central Anatolia, Turkey, to evaluate the effects of different irrigation water levels on forage yield, crop water consumption, and water use efficiency (WUE) of soybean (Glycine max L.), with a focus on sustainable water management. The field experiment was arranged in a randomized complete block design with three replications. Five irrigation treatments were applied: T25 (25% irrigation, 160 mm), T50 (50%, 310 mm), T75 (75%, 470 mm), T100 (100%, 625 mm), and T125 (125%, 780 mm; over-irrigation). Irrigation was performed using a drip system, and irrigation scheduling was based on gravimetric soil moisture measurements within the 0–60 cm soil layer. The seasonal crop evapotranspiration (ETc) values were 210, 370, 520, 680, and 720 mm for T25, T50, T75, T100, and T125, respectively. The results revealed that increasing irrigation levels significantly enhanced forage yield. The highest yield was recorded in T100 (34.98 ton ha^{-1}), followed by T125 (28.30 ton ha^{-1}), T75 (19.30 ton ha^{-1}), T50 (14.40 ton ha^{-1}), and T25 (8.63 ton ha^{-1}). However, excessive irrigation (T125) did not further increase yield and reduced WUE. The average water use efficiency values were 4.11, 3.89, 3.71, 5.14, and 3.93 kg m^{-3} for T25, T50, T75, T100, and T125, respectively. These findings indicate that the 100% irrigation level (625 mm) balanced yield and water productivity. The 75% irrigation level could sustain a high forage yield with approximately 25% less water use. This suggests that moderate deficit irrigation can be a viable strategy for improving water-saving irrigation management under limited water resources. In conclusion, soybean forage yield was extremely sensitive to water availability, and proper irrigation scheduling is crucial to achieving high yield and efficient water use. The study emphasizes that adopting optimized irrigation practices contributes to agricultural productivity and the sustainable management of freshwater resources in semi-arid regions.

Keywords: Soybean, forage yield, irrigation, evapotranspiration, water use efficiency

OP-35. Deep Learning-Based Fruit Detection in Apple Orchards for PLC-Based Regional Spraying

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Abstract

In situations where fruit set varies from tree to tree, applying chemicals to fruitless trees throughout the production season represents a significant cost that producers cannot recoup. Fluctuations in fruit set across production areas and unnecessary chemical use increase agricultural inputs and environmental pollution. This study presents the design and initial validation of a deep learning + PLC-based regional spraying system that optimizes chemical use in apple orchards based on fruit density. Images collected by RGB cameras integrated into the tractor were processed using an SSD architecture based on fastai, and the tree canopy was divided into 4 sub-regions to count apples regionally. The obtained density information was transferred to the PLC controlling the 8 solenoid valve/16 nozzle configuration; the perception-action chain was validated in a laboratory test setup with a ≤3 s trigger delay. The model, trained on approximately 4000 labeled samples, showed >90% accuracy in tests. The system has completed integration and calibration steps with the turbo atomizer. Designed as an economical and widely applicable additional layer to conventional sprayers, the solution aims to reduce unnecessary calcium applications and minimize drift.

Keywords: PLC-controlled pulverization, regional spraying, apple detection, deep learning, digital agriculture

OP-36. Prediction of Soluble Solids Content in Sweet Cherries Using Dielectric Spectroscopy with Convolutional Neural Network

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Abstract

The soluble solids content (SSC) of sweet cherries plays a critical role in determining taste, aroma, and flavor attributes that shape consumer preferences, and it serves as a fundamental parameter for farmers and wholesalers in establishing optimal harvest timing. This study demonstrates the feasibility of predicting SSC through a non-invasive approach by integrating data obtained from dielectric spectroscopy with the Convolutional Neural Network (CNN) model, a deep learning technique. Dielectric properties, including the dielectric constant (ε'), loss factor (ε''), loss tangent ($\tan\delta$), and SSC values, were measured across the 15-300 MHz range using an open-ended coaxial probe during different harvest periods. The developed CNN model, optimized using Bayesian optimization and early stopping, successfully extracted spatial features from hyperspectral dielectric data, exhibiting superior predictive performance. The model achieved notably high correlation and R^2 values: for the E1 dataset (incorporating ε'), test $R^2 = 0.7862$ and test correlation of 0.8975; for the E2 dataset (incorporating ε''), test $R^2 = 0.5668$ and test correlation of 0.9131; and for the Tanloss dataset (incorporating $\tan\delta$), test $R^2 = 0.9099$and test correlation of 0.9566. These results are substantiated by low test MSE (0.6979) and MAE (0.6599) values in the Tanloss dataset, confirming the model's predictive accuracy and generalization capability. The findings indicate that reduced frequency ranges preserve accuracy, and a dielectric measurement system operating with fewer frequencies can enable low-cost, high-accuracy SSC prediction.

Keywords: CNN, non-invasive quality assessment, soluble solids content, dielectric spectroscopy

OP-37. Determining The Effects of Evaporative Cooling System in Tractor Engine and PTO Performance Tests

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Abstract

One of the important rules of tractor engine and PTO performance test of the OECD Code 2 is the ambient temperature must be 23±7 °C during the tests. This rule, which allows tests to be carried out in a wide range of 16-30 °C, causes differences in test results. In other words, the power and fuel consumption of tractors tested at an average temperature of 23 °C differ from those tested at 30 °C. Within the scope of this study, tests were carried out at two different ambient temperatures by changing the ambient conditions with the evaporative cooling system (ECS) in the PTO test laboratory. In Case 1, the ECS was activated, and the ambient temperature was kept at 23°C and succeeded. In Case 2, the ECS was not operated, and the test data was evaluated when the ambient temperature reached 30°C. At the end of the study, the effect of ECS on tractor performance was determined by comparing Case 1 and Case 2. The effects of atmospheric conditions such as ambient temperature, pressure, and humidity on tractor performance were investigated. According to the results of the study, tractors tested with the ECS on showed an increase in PTO power of 1.1–4.0%, hourly fuel consumption of 0.7–3.0%, and specific energy of 0.3–3.4% compared to tractors tested with the ECS off. The change in specific fuel consumption was a (+) 0.8% increase and a (-) 2.4% decrease.

Keywords: OECD Code2 test, tractor performance, evaporative cooling system

Innovative Agricultural Technologies Congress

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Poster Presentations

PP-01. Valuable Compound Recovery from Oak Biomass: A Comparative Study of Pretreatment Techniques

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Abstract

Lignocellulosic biomass derived from agricultural activities remains a significantly underutilized alternative to conventional energy crops for biofuel production. The southern Mediterranean countries are among the world's leading producers of cork, which is harvested from the outer bark of the cork oak tree (*Quercus suber* L.). The industrial processing of cork generates substantial quantities of residual biomass, which present a valuable opportunity for the production of high-value-added products. Oak tree waste is particularly rich in extractives such as polyphenols and triterpenoids*bioactive compounds known for their anti-inflammatory, anticancer, antioxidant, antiviral, antifungal, and antibacterial properties. The valorization of this biomass could enhance the sustainability of the cork industry and contribute to circular bioeconomy strategies.

A critical step in biofuel production from lignocellulosic biomass is pretreatment, which alters the structural integrity of the biomass to facilitate subsequent bioconversion. However, pretreatment also generates a liquid side stream, the valorization of which is crucial for achieving zero-waste goals. In this study, oak tree waste was subjected to four different pretreatment methods: (i) deep eutectic solvent (DES) using choline chloride: formic acid in a 1:2 molar ratio, (ii) acid pretreatment with 2.5% H_2SO_4, (iii) alkaline pretreatment with 2.5% NaOH, and (iv) autohydrolysis. The effects of temperature and treatment duration on the composition of the resulting liquid fractions were evaluated. Solid recovery following pretreatments ranged from 98% to 60%, with higher temperatures and longer durations generally leading to lower recoveries. Among the methods tested, DES pretreatment yielded the highest concentration of phenolic compounds (194.7 mg GAE/g). Acid pretreatment resulted in the highest monosaccharide content, with xylose concentrations reaching 9.6 g/L at 130 °C for 60 minutes. Autohydrolysis was the most effective method for the production of xylo-oligosaccharides (XOS), achieving a maximum yield of 8.7 g/100 g cork oak biomass at 190 °C for 20 minutes.

In conclusion, the type of pretreatment significantly influences the recovery of different value-added products from cork oak waste. This study demonstrates the potential for integrated biorefinery approaches to maximize the utilization of cork industry residues for the sustainable production of biofuels and bioactive compounds.

Keywords: Oak tree waste, lignocellulosic biomass, pretreatment, extraction, phenolics, monosaccharides, oligosaccharides

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PP-02. Optimizing Recirculating Aquaculture System Effluent for Lettuce Production: Nutrient Content and Plant Quality

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Abstract

Traditional soil-based agriculture is facing increasing challenges due to population growth, climate change, and the decreasing availability of arable land and freshwater resources. Soilless cultivation systems such as hydroponics, aeroponics, and aquaponics present promising alternatives by offering more efficient resource use and environmental sustainability. Among these, aquaponics – an integrated system combining fish farming (recirculating aquaculture systems, RAS) with plant cultivation – utilizes fish waste as a nutrient source for plants, reducing the need for synthetic fertilizers and creating a closed-loop ecosystem. However, the nutrient composition of RAS effluents is often suboptimal for plant growth, necessitating further optimization to ensure economic viability and high product quality.

This study focused on the nutritional quality and growth performance of lettuce (*Lactuca sativa* L.) cultivated with RAS-derived solutions from three distinct aquaculture facilities in the Czech Republic and Germany. Three independent experiments were conducted to evaluate (1) the performance of aeroponic vs. hydroponic systems using RAS solutions (MARSONAUT), (2) the impact of chemical supplementation on RAS nutrient solutions (IGB), and (3) the potential of replacing synthetic fertilizers with mineralized aquaponic residues (INOVA). Plant nutrient uptake and quality parameters were assessed, including mineral content (via ICP-OES), photosynthetic pigments and vitamins (via HPLC-PDA), antioxidant capacity (using ORAC and DPPH methods), and polyphenol content (via the Folin-Ciocalteu method).

Results consistently showed that lettuce grown with RAS solutions, even without additional fertilization, exhibited higher antioxidant capacity and elevated levels of health-promoting compounds such as lutein, β-carotene, and vitamin C. However, plants often displayed deficiencies in key nutrients, including potassium (K), iron (Fe), and manganese (Mn), correlating with reduced growth compared to those cultivated with the standard Hoagland solution. Notably, high sodium (Na) levels – attributed to fish feed – were observed in all RAS effluents, sometimes causing mild salt stress, which may have contributed to the increased antioxidant response. Despite these limitations, partial replacement of chemical fertilizers with mineralized organic residues (e.g., fish sludge and tomato plant biomass) successfully maintained plant performance while enhancing ecological recycling of nutrients.

The MARSONAUT experiment demonstrated that integrating aquaponic water into aeroponic systems offers a promising method for enhancing the health benefits of lettuce, as evidenced by improved antioxidant properties. However, plant size and biomass were reduced compared to the hydroponic system. Nevertheless, aeroponics, although requiring stricter environmental control, offers greater environmental sustainability by significantly reducing water input. The IGB study confirmed that supplementing nutrient-deficient aquaponic solution (RAS-F) significantly improved lettuce growth, while maintaining overall quality, though antioxidant capacity—especially ORAC and total phenolics was highest in the unfertilized aquaponic treatment, likely due to stress-induced metabolic responses. The INOVA study provided further evidence that mineralized residues (RAS-M) could replace synthetic inputs resulting in minimal reductions in yield, while enhancing antioxidant capacity and vitamin C content.

Across the hydroponic trials (does not apply for aeroponic system in MARSONAUT), zinc (Zn) uptake was notably higher in lettuce grown on RAS-based solutions, despite similar Zn concentrations across treatments, suggesting that nutrient interactions in RAS water – such as those involving phosphorus, calcium, and iron – may enhance Zn bioavailability.

In conclusion, RAS-derived nutrient solutions, particularly when supplemented or recycled via organic mineralization, offer a viable and sustainable alternative for high-quality lettuce production in soilless agriculture. Although some challenges remain – particularly regarding nutrient balancing and salt management – the findings highlight the potential of aquaponics to contribute meaningfully to sustainable food systems, with added nutritional benefits for consumers.

Keywords: Aquaponics, hydroponics, nutritional quality, food sustainability, antioxidants

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PP-03. Beyond Speed: A Comparative Study on Human Performance and Robotic Potential in Strawberry Harvesting

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Abstract

Introduction: Robotic strawberry harvesters are often benchmarked against human pickers based on pick speed. However, this metric overlooks important factors such as fruit quality, pick accuracy, and consistency. This study compares experienced human pickers working under commercial conditions with university-based pickers and current robotic systems. The aim is to identify where robotic technologies can improve harvesting efficiency, and where human expertise still holds key advantages.

Methods: Data were collected from human pickers on a commercial strawberry farm and a small-scale site at the University of Lincoln using egocentric and exocentric video sources. Eye-tracking glasses and a chest-mounted camera provided a first-person view of picker behaviour, while a 360-degree camera fixed to the picker's trolley captured the surrounding crop environment. These videos were reviewed to assess pick speed, visual attention, and picking strategies, including look-ahead distance and regressive fixations. Pick speed was recorded for 11 pickers across both sites. Quantitative measurements of punnet weight accuracy were taken for two pickers, before and after feedback from in-field quality control (QC) staff. Each punnet had a target weight of 300 grams. Informal interviews with supervisors and QC staff were conducted to contextualise observed behaviours. Comparative data on robotic harvester speed were also reviewed.

Results: In commercial conditions, the fastest human picker reached 58 berries per minute, while the top performer among university-based pickers was around 25 berries per minute. Robotic systems typically harvest fewer than 10 berries per minute. However, human pickers frequently introduced sorting and weight errors. One picker had a mean punnet weight error of 33.92 grams, and another averaged 49.94 grams before QC intervention. Some individual errors exceeded 130 grams, even after intervention. Pickers regularly assessed fruit ripeness by touch, sometimes grasping but not picking berries or turning them to inspect from different angles. While this allowed for informed selection, it also increased handling, which may contribute to bruising or reduced shelf life. In some cases, accessible fruit was missed, particularly in crowded or obscured areas, potentially increasing disease risk and reducing harvest completeness. Interviews confirmed that these issues created additional work for both field-based and packhouse QC teams. Eye-tracking data indicated that faster pickers tended to exhibit greater look-ahead distances and performed fewer regressive saccades than slower pickers, suggesting an advantage in planning and visual search efficiency.

Conclusion: While skilled human pickers continue to outperform robots in speed and nuanced

decision-making, robotic systems offer potential advantages in consistency, reduced handling, and integrated QC. Post-pick rework caused by human error can damage fruit, shorten shelf life, and require additional labour. Robotic platforms have the potential to reduce this burden by performing grading and accurately filling punnets to the target weight during the picking process, although these capabilities are not yet fully realised. Current perception and dexterity limitations mean robots may fail to detect all ripe fruit, particularly when it is partially obscured or requires tactile assessment. As a result, robotic systems should not aim for full coverage alone but work alongside human pickers. A hybrid harvesting model, where robots manage repetitive tasks and humans handle complex or delicate cases, may offer the most practical medium-term solution.

Eye-tracking findings suggest that faster pickers plan their picking sequence more effectively, showing fewer regressive saccades and greater look-ahead distances. This behaviour is mirrored in the latest robotic harvesters, which increasingly assess the full picking scene before initiating action. Such strategies may support improved speed and efficiency in future robotic systems. Future work will quantify the impact of post-pick rework on fruit shelf life and directly assess robotic capabilities in sorting accuracy, harvest speed, and workflow integration.

Keywords: Robotic harvesting, strawberry picking, eye-tracking, quality control, human–robot collaboration

PP-04. Health and Safety Risks of Fresh Meat in Retail

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Abstract

Ensuring the safety of retail meat sale shops is paramount for public health. This study investigates the safety practices and standards of such establishments in Jordan. Through a comprehensive evaluation, encompassing hygiene practices, handling procedures, storage conditions, and regulatory compliance, the aim is to assess the overall safety of these retail meat outlets. The methodology involves extensive field surveys and inspections of a representative sample of meat sale shops across various regions in Jordan. Data collection includes observations, interviews with shop worker, and analysis of regulatory documentation. Statistical analysis techniques are employed to assess the significance of differences in safety practices among different types of shops. Preliminary findings indicate a lack of significant differences in safety practices among the surveyed retail meat sale shops. However, detailed analysis and interpretation of the data are necessary to draw conclusive insights. The results revealed no highly significant differences in the level of HACCP implementation among meat sale shops located in different regions of Jordan. Similarly, sociodemographic variables such as marital status and educational level didn't show a significant impact on HACCP compliance, while workplace area show the higher between them. These findings suggest a uniformity in the adherence to HACCP standards across diverse sociodemographic backgrounds in the Jordanian context. The implications of these findings for public health policy, regulatory enforcement, and consumer awareness are discussed. It contributes to the understanding of the current status of meat sale shop safety and provides recommendations for improving safety standards and regulatory compliance in this crucial sector.

Keywords: Retail meat, HACCP, food safety

PP-05. Agronomic Response of Horticultural Crops Under Agrivoltaic Systems: First Insights from a Mediterranean Climate

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Abstract

The Horizon Europe SYMBIOSYST project (no. 101096352) addresses these issues by pioneering integrated agrivoltaic solutions that harmonize agricultural productivity with renewable energy generation. This study presents the first empirical evaluation of photovoltaic (PV) structure configurations on horticultural crops in the Mediterranean region of Barcelona, Spain. Two commercial lettuce varieties (*Lactuca sativa* L.) were assessed under three different radiation regimes: 1) unshaded (control); 2) conventional opaque PV modules; and 3) PV modules with enhanced light transmission.

The PV structures were mounted on automated solar trackers that followed the sun's path throughout the day. Each PV array was connected to an electrical control panel that continuously recorded electrical energy generation. Real-time energy production data were logged via MODBUS gateways and a 4G LTE network, enabling remote system monitoring.

Plant size, biomass, and chlorophyll content were measured for the agronomic evaluation, and complemented with vigor data from a portable camera and a ground-based robot equipped with RGB and multispectral sensors. Values for light distribution, soil irradiance and albedo, photovoltaic module surface temperature, and soil microclimate were recorded too. These datasets were used to develop models simulating the incidence of radiation in the cultivation environment.

Preliminary results reveal differences in vegetative response depending on the type of shading applied, although further trials at different times of the year are needed to evaluate the effects. This work also demonstrated that the combined use of in situ sensors and imaging is a promising tool for decision-making in complex agrivoltaic systems. Future trials will expand on these findings, exploring seasonal variability and crop-specific adaptations.

Keywords: Renewable energy, solar trackers, environmental monitoring, agricultural robotics, digital twin, plant physiological response, agronomic productivity

PP-06. Design and Performance Evaluation of Sustainable Duster Equipment Prototype for Sulfur Based Plant Protection in Date Palm Trees

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Abstract

This work focuses on designing of the agricultural duster for sulfur-based plant protection in the date palm trees. The investigation was performed using two main working parameters included three working pressures (10, 15 and 20 bar) which required to emerge the sulfur powder to tree canopy, and six types of outlet gates geometric (circular, rectangular, fan-shaped, tapered longitudinal, square operings, and interlaced openings) arrangements through which dust powder is discharged. The Prototype of duster was subjected to controlled experiments in an attempt to measure the variability of the following critical performance parameters including the actual discharge rate, effective dust width, treated distribution area, and powder spread angle. The completely randomized design was used to analyse effect of parameters studied. The findings of the work are expected to provide useful insights for designing duster applicators more efficiently, uniformly, and sustainably for using in the palm trees. The prototype design involves a significant increase in the efficiency of sulfur dusting by reducing the amount applied on the trees in comparison to tradition method. The results also illustrated that the fan-shaped gate generated the largest average in effective dusting width, the largest spread powder angle, the biggest performance in spread area at all investigated pressures and are less sensitive to operating pressure. This outcomes in an improvement in environmental impact and the worker's' health conditions. However, the dusting equipment can represent a safety risk for the workers because of their interaction with the parameters used.

Keywords: Agricultural duster, operation parameters, Powder flow dynamics, dust distribution uniformity, tree canopy

PP-07. CMD-YOLO: A Rapid Classification and Recognition Model for Chili Fruit Maturity Integrating Lightweight Design and Multi-Scale Feature Enhancement

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Abstract

To address the challenges of low classification accuracy, high computational complexity, and difficulties in deployment on edge devices for maturity recognition of Dongshan smooth-skinned chili peppers, this study proposes a lightweight detection model named CMD-YOLO (Chili Maturity Detection-YOLO), based on an improved YOLOv11n architecture. The aim is to achieve fast and accurate maturity recognition and localization for automated harvesting of this specific pepper variety. The proposed method systematically optimizes the baseline YOLOv11n model across three key aspects: the backbone network, the feature fusion structure, and the downsampling strategy. First, the lightweight vision Transformer network EfficientViT is introduced to replace the original backbone, significantly reducing both parameter count and computational overhead while improving inference efficiency. Second, a C3k2_ConvFormer module is incorporated into the neck network to combine convolutional operations with cross-attention mechanisms, enhancing multi-scale contextual awareness and expanding the receptive field, which effectively improves the detection performance for small and occluded fruits. Finally, progressive spatial convolution (PSConv) is adopted to replace standard convolutional downsampling, better preserving fine edge and texture features of peppers and strengthening the model's spatial representation capacity. Experimental results demonstrate that CMD-YOLO achieves precision (P), recall (R), mAP50, and mAP50-95 values of 92.9%, 86.1%, 94.4%, and 75.3%, respectively, on a self-built dataset of Dongshan smooth-skinned chili peppers, with a model size of only 3.66M parameters. Compared to the original YOLOv11n, the proposed model improves precision and mAP50 by 1.4 and 2.5 percentage points, respectively. In comparative experiments with mainstream models such as RT-DETR, YOLOv8n, YOLOv10n, and YOLOv13, CMD-YOLO exhibits superior overall performance in terms of accuracy-speed trade-off, particularly showing enhanced maturity recognition capability under occlusion and varying lighting conditions. Furthermore, when deployed on a GUI-based visual platform, the model achieves a per-frame inference time of less than 0.3 seconds. Tests on both the self-built dataset and a public chili pepper dataset from Kaggle confirm the model's strong robustness and generalization ability. These findings indicate that CMD-YOLO successfully balances lightweight design with high accuracy, meeting the requirements for real-time detection in natural environments and providing reliable technical support for visual perception and decision-making in automated chili pepper harvesting robots.

Keywords: YOLO; maturity identification; object detection; chili; lightweight model

PP-08. Smart Sensing for Food Quality Assessment: Integration of Multimodal Data and Model Fine-Tuning

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Abstract

Canola seed quality plays an important role in processing of high-quality oil and can significantly impact the oil extraction yield. Therefore, accurate prediction of canola seed quality at pre- and post-harvest stages shows a vital role in precise decision-making. Current canola seed quality assessments are often inefficient, task laborious, time-consuming, and more prone to human errors. Therefore, in this study a novel end-to-end framework for predicting canola seed quality both physical and chemical parameters was developed. This research incorporated the most recent advancements in computer vision and machine learning to develop a comprehensive canola quality prediction system. The advanced spectral imaging coupled with Artificial Intelligence (AI) modeling for precise prediction of canola quality parameters and precise tracking via ByteTrack algorithm. A modified object detection model was developed and enhanced with convolutional block modules and ghost layers to achieve higher performance in seed damage detection. This resulted in simultaneous prediction of canola damaged seeds and reducing complexity of the model to 35%. Compared to the original model, the developed condensed model was not only smaller in size but overperformed by speed (>24 FPS), cost (78 GFLOPs) and increased the Mean Average Precision by 2%. These results indicate the novelty of this research and provide an efficient tool for rapid, accurate and robust canola quality assessment.

Keywords: Computer vision, spectral imaging, modelling

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