



2022 IEEE INTERNATIONAL WORKSHOP ON

Metrology for Agriculture and Forestry



NOVEMBER 3-5, 2022

PERUGIA, ITALY

PROGRAM

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Welcome Message from the General Chairs

On behalf of the Organizing Committee, we cordially welcome you to the 2022 IEEE International Workshop on Metrology for the Agriculture and Forestry (*MetroAgriFor 2022*).

MetroAgriFor 2022 intends to create an active and stimulating forum where academics, researchers, and industry experts in measurement and data processing techniques for Agriculture, Forestry, and Food can meet and share new advances and research results.

Attention is paid, but not limited to, new technologies for agriculture and forestry environment monitoring, food quality monitoring, metrology-assisted production in agriculture, forestry and food industries, sensors and associated signal conditioning for agriculture and forestry, calibration methods for electronic test and measurement for environmental and food applications.

The first edition of *MetroAgriFor* was hosted by Polytechnic University of Marche, Italy, from an insightful and brilliant idea of Professor Enrico Primo Tomasini. He served as the first General Chair of this adventure. The Department of Agricultural Sciences, University of Naples "Federico II", Italy, hosted the second edition of the Workshop, with Leopoldo Angrisani, Pasquale Daponte and Matteo Lorito as General Chairs. The 3rd edition of *MetroAgriFor* was originally planned to be held in Trento (Italy), hosted by the University of Trento. However, due to the COVID-19 emergency, we were forced to organize this edition as a virtual conference. The virtual Workshop was planned to make an online conference, with a virtual environment where the attendees could present their papers, and could be engaged interacting in all sessions and activities. A special thanks to the organizing team, who professionally addressed this issue. Finally, the 4th edition was again in presence, and it was hosted in Trento during the first two days, and in Bozen/Bolzano on the last day.

This year the fifth edition of *MetroAgriFor* is hosted in the green heart of Italy. The University of Perugia welcome you all to the Department of Agricultural, Food and Environmental Sciences, DSA3, founded in 1896 and located in the ancient Benedictine Abbey of San Pietro, in the center of the city. The DSA3 is included in the list of the Italian Department of Excellence with constantly growing engagement in the research topics of the workshop. The program is arranged to offer the possibility of visiting Perugia and its artistic and beautiful natural landscapes.

The *MetroAgriFor* Technical Program consists of 74 oral presentations scheduled over three days. Presentations are organized in a General Session and 11 Special Sessions. Special Sessions aim to create a focus on specific topics, where researchers can make knowledge, familiarize, exchange ideas, and build cooperation.

The received extended abstracts were submitted to a peer-review process. Relevance, quality, significance, and novelty of the scientific contribution were the main attributes taken into consideration for acceptance and publication in the Proceedings. The Proceedings are going to be

submitted for publication in the IEEEExplore Digital Library. We would like to thank all the reviewers who actively contributed to the selection and quality improvement of the presented works.

Technically extended versions of presented papers can be submitted to:

- Journal of Agricultural Engineering (JAE), the official journal of the Italian Association of Agricultural Engineering (AIIA). JAE is supporting *MetroAgriFor* with two main initiatives; (i) a JAE *MetroAgriFor* Special Mention & Award will be assigned by an international evaluation board to the best paper on topics related to agricultural and forestry engineering among those presented by young researchers (<30 years old), the Award will consist on a bonus for a free-charge publication on JAE within the next 2 years, and (ii) the same international evaluation board will select a set of 12 papers to be potentially included, after a regular review process, in a JAE Special Issues on “*Matching metrology and management issues in agricultural and forestry engineering applications*”.
- Special Issue on MDPI Sensors, the topics of interest for this Special Issue include but are not limited to precision agriculture, precision horticulture, smart agriculture, metrology for farm pest control, Smart water management in agriculture, smart farm, and so on.

MetroAgriFor 2022 is honoured to have experts in smart agriculture and forestry as Invited Speakers.

- Prof. Arnon Dag, Agricultural Research Organization, VOLCANI Center Ministry of Agriculture, Israel, will open the Workshop with a talk about *Canopy-cooling systems applied on fruit trees for climate change adaptation*.
- Prof.ssa Stefania De Pascale, Department of Agriculture Sciences – University of Naples Federico II, Italy, will open the second day of works with a talk about *Smart plant cultivation for space exploration, goals, and challenges*.
- Dott.ssa Emanuela Del Dottore, PhD, Bioinspired Soft Robotics Laboratory, Italian Institute of Technology, Italy, will open the last day with a lecture on *From Nature to Nature through Robotics*.

We are grateful to the Invited Speakers for joining the Workshop.

During the Workshop, attendees have the possibility to follow three Tutorials on *Advanced remote sensing techniques to monitor steep-slope viticulture under climate change scenarios* by Prof. Paolo Tarolli, University of Padua, Italy, *Digital image processing algorithms and concrete application*, Prof. Gianluca Vinti, University of Perugia, Italy, *Autonomous Mobile Robots for Crop Monitoring* by Gabriele Costante, Department of Engineering, University of Perugia, Italy.

MetroAgriFor 2022 is pleased to host the Round Table on the PNRR Agritech - SPOKE 3 with the participation of Prof. Gabriele Cruciani, Delegate for the third mission sector, University of Perugia; Prof. Daniele Porena, Delegate for the sector Reforms, simplification and legal support, University of Perugia; Prof. Luca Corelli Grappedelli, Coordinator PNRR Agritech - SPOKE 3, University of Bologna; Prof. Francesco Tei, Coordinator DSA3 per SPOKE3_Agritech, University of Perugia.

To recognize the most outstanding paper presented at the annual *IEEE International Workshop on Metrology for Agriculture and Forestry*, the Best Conference Paper Award will be assigned. Other



awards will be assigned to the Best Paper presented by a Young Researcher, to the Best Paper Presented by a Woman to recognize the full engagement of women in all aspects of the Metrology in Agriculture and Forestry, and to the Best Paper presented as a Poster.

We sincerely want to thank all the sponsors and the patronages who made this event possible.

The 2022 IEEE International Workshop on Metrology for Agriculture and Forestry is about to begin. Metrologists, agriculture, forestry, food experts, and engineers, enjoy the Workshop!

November 2022

Francesca Todisco, University of Perugia, Italy
Angelo Frascarelli, ISMEA, University of Perugia, Italy
MetroAgriFor2022 General Chairs

Message from the Technical Program Chairs

Welcome to the 2022 IEEE International Workshop on Metrology for Agriculture and Forestry (MetroAgriFor 2022), organized by the University of Perugia (Italy). MetroAgriFor previous editions were held in Ancona (2018), Portici (2019), due to the COVID-19 pandemic online (2020), and Trento and Bozen/Bolzano (2021). MetroAgriFor established itself as an important world forum for discussing the latest advances in metrology for agriculture and forestry.

The Technical Program of MetroAgriFor 2022 has 74 papers divided into 12 sessions distributed over the three days of the workshop. Special sessions aim at creating mini-workshops on specific topics where researchers working on the same area can be aware with each other's contributions to the creation of knowledge beyond the current state of the art. MetroAgriFor launched a call for special sessions and received a variety of different proposals from the session chairs.

- Special Session #1: Navigation, georeferenced spatial data acquisition and analysis in precision agriculture
- Special Session #2: Innovative robotics solutions and autonomous tasks for agro-forestry applications
- Special Session #3: Digital technologies in agricultural, livestock and food-processing facilities
- Special Session #4: Making steep-slope vineyards more sustainable: contributions from new technologies
- Special Session #5: Platforms for integrated analyses of agro-ecosystems
- Special Session #6: Technologies for monitoring animal behaviour and its surrounding environment
- Special Session #7: ICT application in the energy, industrial and biorefineries chains based on wood and lignocellulosic biomass

- Special Session #8: Gaseous emissions in livestock production: advances in measurement and modelling from barn to the field
- Special Session #9: Precision horticulture
- Special Session #10: Remote sensing and hydrological models for irrigation water use assessment
- Special Session #11: Animal science and food products of animal origin: the role of measurement
- Special Session #12: Sensors and technologies for the smart agricultural water management
- Special Session #14: Artificial intelligence, innovative data analysis and big data for agriculture and food applications
- Special Session #15: Contactless measurements, edge computing and computer vision for agriculture, forestry and zootechnics
- Special Session #16: Measurement of soil water erosion at different spatial scales
- Special Session #17: Measurements for risk management in agriculture

The Technical Program includes a Round Table on on the PNRR Agritech.

We gratefully acknowledge the hard work of the Technical Program and Organizing Committees in the process of reviewing the papers and helping to shape the program and other activities, such as keynotes and tutorials. The International Program Committee is composed of dozens internal experts in the area of agriculture and forestry measurements. Also, we thank the dozens of reviewers who accepted to review papers in their specific expertise. Finally, we especially thank authors who honoured the 5th edition of MetroAgriFor, submitting high-quality contributions with their research results. All these people played an important role in making this Workshop to come through.

We wish all participants a very enjoyable and professionally fruitful experience at MetroAgriFor 2022, where finally we have the opportunity to meet you all in person!!

Thanks to you all for your participation.

November 2022

Gianluca Rossi, *University of Perugia, Italy*

Alberto Garinei, *Università degli Studi Guglielmo Marconi, Italy*

Javier Tardaguila, *Universidad de La Rioja, Spain*

MetroAgriFor2022 Technical Program Chairs



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IEEE MetroAgriFor 2022 Keynote Speakers

Plenary Session - Thursday, November 3, 2022 - H 14:30

Canopy-cooling systems applied on fruit trees for climate change adaptation

Prof. Arnon Dag

Agricultural Research Organization, Volcani Center Ministry of Agriculture, Israel



ABSTRACT

Climate change is one of the modern threats to agriculture and food security. The air temperature on earth has been constantly increasing during the last decades; according to the intergovernmental climate change panel (IPCC), global warming of 1.5°C is predicted in the next 10-30 years. The Mediterranean region has been identified as one of the world's most vulnerable and susceptible regions to climate change. In this region, besides general warming, spring heatwaves from the desert have become common. The combination of high temperatures, wind and low humidity is problematic for subtropical crops adapted to high humidity and temperate climate. Several methods were previously suggested to help fruit trees cope with heat stress, among them using heat-tolerant rootstocks, net shading, particle film application, fertilization manipulation and supplementary irrigation (Mupambi et al. 2015). Most of these methods are time-consuming, and/or entail additional expenses. The unpredictable nature of heatwaves requires an efficient, low-cost method, which should be available for immediate use, responsive and easy to implement. The above-canopy evaporative cooling method has been studied for several decades as a potential solution for crop protection against drought and heat stress. This method explores sprinkling operated above the crop canopy, which effectively reduces air and leaf temperatures through latent heat transfer, thereby reducing VPD. The method is especially effective in hot and dry climates. Therefore, short-term treatment can reduce plant damage during extreme heatwaves. However, adapting the method to a specific crop at a specific developmental stage, under specific climatic conditions is not straightforward. A specific test case in developing the use of evaporative cooling in avocado will be presented.

SPEAKER BIO

Prof. **Arnon Dag** is the Deputy Director is The Center for Arid and Semi-Arid Agricultural, The Volcani Institute, Ministry of Agriculture, Israel. Prof. Dag is a Senior Researcher the Department of Fruit Tree Sciences, Institute of Plant Sciences of the Agricultural Research Organization. He obtained his M.Sc. degree from Tel Aviv University and his Ph. D. degree from The Hebrew University of Jerusalem's Faculty of Agriculture in Rehovot. He worked for 10 years in the Extension Service of the Ministry of Agriculture before joining the ARO as a researcher. His main research interest is pomology under arid conditions and especially olive, avocado, jojoba, table grapes and pomegranates biology and cultivation with special attention spent tree – soil - water relationships under arid

conditions. He was the Scientific Director of R & D South, Israel (which specialized in intensive agriculture under desert conditions) for 6 years. His research activity has resulted in more 130 papers in peer review journals and 100 papers in local journals. He was the convener of the Agritec, Desert Agriculture conference (2018) 9th ISHS International Symposium on Mineral Nutrition of Fruit Crops (2021) and Achieving Sustainable Agriculture in Arid Regions conference (2021). Prof Dag also teaches the Desert Agriculture course in Tel Aviv University (2016-2019)

Plenary Session - Friday, November 4, 2022 - H 09:00

Smart Plant Cultivation for Space Exploration: Goals and Challenges

Prof. Stefania De Pascale
University of Naples Federico II, Italy



ABSTRACT

Human exploration beyond Low Earth Orbit (LEO) will require technologies regenerating resources like air and water and producing fresh food while recycling consumables and waste. Bioregenerative Life Support Systems (BLSSs) are artificial ecosystems in which appropriately selected organisms, including bacteria, algae and plants, are assembled in consecutive steps of recycling, to reconvert the crew waste into oxygen, potable water and edible biomass. Bioregenerative life support systems have been discussed since the early 20th century. Central to the concept is the use of photosynthetic organisms to regenerate air and food. Plants are considered the most promising biological regenerators to accomplish these functions, thanks to their complementary relationship with humans. BLSSs implementation starts with small plant growth units (i.e. salad machines) to produce some fresh foods to supplement stowed food for astronauts onboard the International Space Station or during early lunar missions. The cultivation area will then be expanded for longer duration lunar missions, which will also provide an opportunity to test systems and procedures for Mars missions, where BLSSs would play a more crucial role. However, cultivation in Space requires the knowledge of plants' responses to Space factors (e.g., altered gravity and ionizing radiation) and the optimization of the cultivation environment (e.g., light quantity and quality, CO₂ concentration, growing medium, water and nutrient delivery system). The presentation summarizes the research activity carried out at the Department of Agricultural Sciences of the University of Naples Federico II on plant-based BLSSs thanks to projects funded by the Italian Space Agency (ASI) and by the European Space Agency (ESA) within the Micro-Ecological Life Support System Alternative (MELiSSA) program.

SPEAKER BIO

Stefania De Pascale is Professor of Horticulture at the Department of Agricultural Sciences in the University of Naples Federico II. She is also the vice-president and a member of the board of directors of the National Council for Agricultural Research and Economics (CREA). She teaches in courses on Vegetable crops production, Crop physiology, Greenhouse horticulture and supervises BSc, MSc and PhD students. She taught in international intensive courses on greenhouse horticulture and crop physiology. Since Stefania joined the Department in 1993, she has performed numerous researches both in field and in greenhouse to determine the effects of

environmental and cultural factors on plant growth and development and on produce quality of a wide range of vegetable and ornamental crops. Twenty years ago, she and her team started to study the use of plants for food and oxygen production, CO₂ regeneration and water purification and the effects of “Space environment” on plants. From 2019, Stefania is the responsible of the Research Laboratory on Plant for Space including the MELISSA Plant Characterization Unit conceived as a crop research facility within the MELISSA project, which is a joint long-term effort, led by the ESA, focused on the development of a regenerative life-support system for air, water and food production in the sight of future long-term manned missions to Moon and Mars. www.melissafoundation.org.

Plenary Session - Saturday, November 5, 2022 - H 09:30

From Nature to Nature through Robotics

Dr Emanuela Del Dottore

*Bioinspired Soft Robotics Laboratory
Italian Institute of Technology, Italy*



ABSTRACT

Bioinspiration is a long-lasting approach increasingly adopted in robotics to inspire novel, emerging technologies and robotic systems expected to interact more safely with natural unstructured environments and living beings, better dealing with uncertain and dynamic conditions.

In particular, plants structural and functional properties, and their energy-saving strategies to move across unknown and challenging environments through adaptive growth, make plants a unique, novel model for roboticists. Plants explore and colonize their surroundings, overtaking obstacles and moving in a complex medium like roots in the soil or cluttered environments on the aerial side. They elaborate on many different chemical and physical signals from the outside. As a response, they display a series of growth movements and decision-making strategies whose engineering translation has proven to enable new abilities for improved motion and exploration of bio-inspired growing robots. For example, results of a deep study on a peculiar movement observed in plant roots, i.e., circumnutation, demonstrate its role in optimizing soil penetration. The “growth from the tip” adopted by this biological model has been verified to facilitate soil penetration in artificial penetrometers imitating the addition of new material at the tip via embedded additive manufacturing techniques while enabling passive body shaping. Strategies of self-orientation and environmentally driven growth have been translated into effective explorative control strategies for these plant-inspired autonomous systems.

Plants are viable models for engineering novel artificial systems, enabling new abilities for dynamic adaptation helping to reduce forces and energy employed in exploration tasks for application in agriculture, space, or Earth exploration and monitoring.

SPEAKER BIO

Dr. **Emanuela Del Dottore** is a Researcher in Bioinspired Soft Robotics at the Istituto Italiano di Tecnologia (IIT), Italy. With a background in Computer Science (University of Pisa) and a Ph.D. in Biorobotics (cum laude, from Scuola Superiore S. Anna, Pisa), she works on the development of control and decision-making strategies for bioinspired robots based on plants growth behaviors. Dr. Del Dottore has contributed to writing successful regional and international project proposals and participated in their development. These include, for instance, FET-OPEN FP7-ICT PLANTOID (G.A. 293431), FET-PROACT GROWBOT (G.A. 824074), ERC I-WOOD, POR FESR Toscana SMASH. She is co-advisor of several Ph.D. students, fellows, research interns, and postdocs working in plant-inspired robotics, growing robots, and soft robotics. Dr. Del Dottore is currently working on analyzing plant behaviors to implement plant-inspired computational models useful for the distributed control and communication of multi-agent systems. Her goal is to extract functional rules from natural living systems and implement similar functionalities to enable efficient compliance and adaptation in robotic artifacts to explore and monitor unstructured and mutable environments.

IEEE MetroAgriFor 2022 Tutorials

Tutorial - Thursday, November 3, 2022 - H 17:30

Advanced remote sensing techniques to monitor steep-slope viticulture under climate change scenarios

Prof. Paolo Tarolli
University of Padua, Italy



ABSTRACT

Steep-slope agricultural areas are often cultural landscapes where cultivation takes place according to traditional knowledge. They are sometimes inscribed in recognized protection lists, such as UNESCO-WHS or FAO-GIAHS. In the Mediterranean basin, slopes are often cultivated with vines, significantly contributing to the economy of entire geographical areas. Such vineyards are the result of the layering of several agricultural patterns over centuries of history, assuming complex morphologies, therefore intrinsically susceptible to slope instabilities. Climate change can amplify this criticality. It can be a threat to these fragile environments, mainly due to the intensification of intense rainfall events that trigger soil erosion, but also to periods of drought that represent a rising critical issue for the entire agricultural sector (e.g., the impact of the drought of 2022 in Europe). This complex overview makes it necessary to increase vineyard sustainability, inviting stakeholders to invest in water and soil conservation measures. The application of recent high-tech devices can help to understand the processes occurring on terrain surfaces. New frontiers in Earth observation include remote sensing techniques such as Uncrewed Aerial Vehicles (UAVs) and airborne laser scanners, which supply a three-dimensional reconstruction of surfaces. GIS-based analyses and high-resolution simulations provide a spatial view of the information obtained, combining them into valuable products for decision-making. This seminar focuses on some examples where key analyses involving new remote sensing technologies have been carried out to make the so-called "heroic viticulture" more resilient to climate change.

SPEAKER BIO

Paolo Tarolli is Full Professor in Soil & Water Conservation and Agricultural Water Management at the University of Padova (Italy). He is also Visiting Professor at Dalian University of Technology (P.R. China), and Adjunct Professor at University of Georgia (USA) and Alexandru Ioan Cuza University of Iași (Romania). He is Vice President of Soil and Water Conservation Division of Italian Society of Agricultural Engineering (AIIA), and he was Deputy President of the Natural Hazard division (EGU) from 2019 to 2022. He is an expert in digital terrain analysis, earth surface processes analysis, natural hazards, geomorphology, hydro- geomorphology, lidar, structure-from-motion photogrammetry; new research directions include the analysis of topographic signatures and the impact of human activities, focusing on agricultural landscapes & land degradation. Tarolli is Chief Executive Editor of Natural Hazards and Earth System Sciences, and Associate Editor of International Soil and Water Conservation Research, Land Degradation & Development, Remote Sensing. He is the author of more

than 150 articles published in international peer-reviewed journals and books. He is ranked in the list of 100,000 top world's most cited scientists (source Scopus by Elsevier BV).

Tutorial - Friday, November 4, 2022 - H 16:50

Digital image processing algorithms and concrete application

Prof. Gianluca Vinti
University of Perugia, Italy



ABSTRACT

During this tutorial I will discuss some algorithms for the reconstruction and the processing of digital images, focusing in particular on one recently introduced and successfully applied in various fields. I will examine them focusing in particular on the processing of thermographic images for the study of the seismic vulnerability of buildings and giving a quick reference to the estimation of thermal bridges for the energy saving.

SPEAKER BIO

Gianluca Vinti is Full professor of Mathematical Analysis at the Department of Mathematics and Computer Science at the University of Perugia (Italy) from 2001 and from 2019 he is the Director of Lamberto Cesari Interdepartmental Research Center. From 2014 till 2019 he has been the Director of the Department of Mathematics and Computer Science of the University of Perugia. To date he is Member of the Academic Board of the Ph.D. in Mathematics, Computer Science, Statistics organized in consortium among the University of Perugia (Italy), University of Florence (Italy) and the INdAM (National Institute of Higher Mathematics), Coordinator for the Mathematics of the Educational Centre of the "Accademia Nazionale dei Lincei" at Perugia, Member of the Scientific Commission of the Italian Mathematical Union (UMI) and Coordinator of the UMI commission "Scientific Meetings". He coordinates a research group, consisting of 2 Full Professors, 5 Associate Professor, 3 Assistant Professors, 1 Post doc student, 4 PHD Students, which deals with Real Analysis, Functional Analysis, Approximation Theory and its applications to Signal/Image Processing with reference to biomedical images (CT images) for the diagnosis of vascular pathologies, (AOCT images) for the diagnosis of retinopathies, (RNM images) for the diagnosis of Alzheimer's disease and image diagnostics for the study of the seismic vulnerability of buildings (image textures), for the evaluation of their energy efficiency (study of thermal bridges) and for the study and localization of acoustic sources (acoustic bridges). He has been invited to hold more than 100 plenary talks at conferences and seminars at various universities and research centers, including: Aachen (Germany), Bedlewo (Poland), Czestochowa (Poland), Koln (Germany), Kraków (Poland), Madrid (Spain), Orleans (France), Poznan (Poland), S. Francisco (USA), Toronto (Canada), Thessaloniki (Greece), Trondheim (Norway), York (U.K.), Sibiu (Romania) and many others, in addition to the major Italian universities. He belongs to the Editorial Board of several international mathematical journals.

Tutorial - Saturday, November 5, 2022 - H 14:00

Autonomous Mobile Robots for Crop Monitoring

Prof. Gabriele Costante
University of Perugia, Italy



ABSTRACT

Autonomous robots have established as a ground-breaking technology for precision farming (PA), particularly for resource optimization and labor savings. One of the most important aspects of PA that benefits from robotic solutions is certainly crop monitoring. Robotic platforms such as All-Terrain Vehicles (ATVs) and Unmanned Aerial Vehicles (UAVs) can now be equipped with high throughput embedded computers (also with GPUs) that open further possibilities for automatic inspection and, more generally, for smart agriculture. To close the gap with human capabilities, robots must use their perception systems to achieve three main goals: navigate the operational scenario, collect information, and process it. Unlike urban or indoor scenarios, agricultural settings offer specific challenges that must be considered when developing an autonomous monitoring platform. These include the presence of rough terrain, variable operating conditions (e.g., weather, lighting), and repetitive and non-discriminative objects that make localization and navigation more difficult. In this tutorial, the characteristics of a robotic platform for crop monitoring will be described, highlighting the hardware specifications, the sensors required to collect information about the surrounding environment, and the algorithms needed to enable the robot's autonomy and allow the processing of collected data. Different monitoring applications will be presented, including normalized vegetation difference index (NDVI) computation for prescription maps and olive fly infestation detection. As a case study, a ground robotic platform, developed as part of a research project, will be considered and presented after the tutorial session, showing examples of data acquisition sessions.

SPEAKER BIO

Gabriele Costante received the Master degree in 2012 and the Ph.D. degree in information engineering in 2016 from the Department of Engineering, University of Perugia, Italy. He is currently a Senior Researcher (RTD-B) with the Intelligent Systems, Automation and Robotics Laboratory (ISARLab) at the Department of Engineering of the University of Perugia. In 2014 he has participated as a visiting researcher in the activities of the Robotics and Perception Research Group of the University of Zurich (Zurich, Switzerland). He has co-authored more than 40 scientific papers in international journals and conferences. He is currently member of the Academic Board of the Ph.D. in Industrial and Information Engineering at the Department of Engineering, University of Perugia and lecturer of the courses "Computer Vision and Robot Perception" and "Machine Learning and Data Analysis" within the master degree in Informatics and Robotics Engineering. He has participated and is currently active, also with management responsibilities, in several national and international projects with universities and companies. He is also involved in different editorial activities and scientific committees and is co-founder of the academic spin-off Red Lynx Robotics s.r.l.. His research interests include artificial intelligence, robotics, computer vision, and machine learning with applications in several contexts including healthcare, agriculture, logistic and industry.

IEEE MetroAgriFor 2022 Venue

The workshop will be held in the Aula Magna of the Department of Agricultural, Food, and Environmental Sciences (DSA3) of the University of Perugia (Italy).

The conference venue is part of the monumental complex of the San Pietro Abbey in Perugia, which is located in the southern part of the historic city center and within a walking distance of many restaurants, hotels, and B&B.

The Abbey of Saint Peter, which is part of the 15th century expansion of the city walls, is located opposite the Giardini Frontone in Perugia, at the end of Borgo XX Giugno, outside the Porta San Pietro and was once the most powerful Benedictine monastery in Umbria. It was founded in the 10th century and was the first seat of the Bishop of Perugia.



Address

University of Perugia - Abbazia di San Pietro
Borgo XX Giugno, 74,
06121 – PERUGIA, Italy

IEEE MetroAgriFor 2022 Social Events

WELCOME PARTY

Thursday, November 3, 2022

H 19:00

The IEEE MetroAgriFor 2022 Welcome Party will be held at **Restaurant Collins' at Hotel Sina Brufani** - Piazza Italia, 12 - Perugia. Restaurant Collina @ Hotel Sina Brufani is about 15 minutes walking from the Conference Venue.



Address: Restaurant Collins' at Hotel Sina Brufani

Piazza Italia, 12
06121 Perugia

GALA DINNER

Friday, November 4, 2022

H 20:00

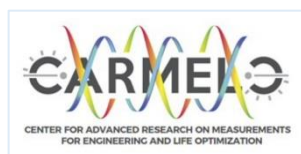
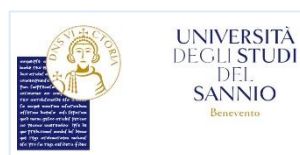
The Gala Dinner will be held at Restaurant **Del Sole** - Roma. The restaurant is about 15 minutes walking from the Conference Venue.



Address: Restaurant Del Sole

Via della Rupe, 1
06121 Perugia

IEEE MetroAgriFor 2022 Patronages



IEEE MetroAgriFor 2022 Sponsors



Program Schedule - Thursday, November 3

THURSDAY - NOVEMBER 3			
14:00 - 14:30	Opening Ceremony <i>Room: Aula Magna</i>		
14:30 - 15:30	Plenary Session #1 Canopy-cooling systems applied on fruit trees for climate change adaptation Prof. Arnon Dag, <i>Agricultural Research Organization, Volcani Center Ministry of Agriculture, Israel</i> <i>Room: Aula Magna</i>		
15:30 - 15:50	COFFEE BREAK		
	Aula Magna	Aula Riviste	Aula Periodici
15:50 - 17:30	Session 1.1 - Special Session #7: ICT application in the energy, industrial and biorefineries chains based on wood and lignocellulosic biomass	Session 1.2 - Special Session #8: Gaseous emissions in livestock production: advances in measurement and modelling from barn to the field	Session 1.3 - Special Session #13: New advancements and integrations of observation systems for monitoring hydrological processes and for supporting the sustainable management of agro-forest systems
17:30 - 18:10	Tutorial #1 Advanced remote sensing techniques to monitor steep-slope viticulture under climate change scenarios Prof. Paolo Tarolli, <i>University of Padua, Italy</i> <i>Room: Aula Magna</i>		
19:00	Welcome Party		

Program Schedule - Friday, November 4

FRIDAY - NOVEMBER 4			
09:00 - 10:00	Plenary Session #2 Smart Plant Cultivation for Space Exploration: Goals and Challenges Prof. Stefania De Pascale, <i>University of Naples Federico II, Italy</i> <i>Room: Aula Magna</i>		
10:00 - 11:20	Round Table Room: Aula Magna		
11:20 - 11:40	COFFEE BREAK		
	Aula Magna	Aula Riviste	Aula Periodici
11:40 - 13:20	Session 2.1 - General Session	Session 2.2 - Special Session #3: Digital technologies in agricultural, livestock and food-processing facilities	Session 2.3 - Special Session #14: Artificial intelligence, innovative data analysis and big data for agriculture and food applications
13:20 - 14:30	LUNCH		
	Aula Magna	Aula Riviste	Aula Periodici
14:30 - 16:30	Session 3.1 - Special Session #5: Platforms for integrated analyses of agro-ecosystems	Session 3.2 - Special Session #9: Precision horticulture	Session 3.3 - Special Session #15: Contactless measurements, edge computing and computer vision for agriculture, forestry and zootechnics
16:30 - 16:50	COFFEE BREAK		
16:50 - 17:30	Tutorial #2 Digital image processing algorithms and concrete application Prof. Gianluca Vinti, <i>University of Perugia, Italy</i> <i>Room: Aula Magna</i>		
20:00	Gala Dinner		

Program Schedule - Saturday, November 5

SATURDAY - NOVEMBER 5			
09:30 - 10:30	Plenary Session #3 From Nature to Nature through Robotics Emanuela Del Dottore, PhD. Italian Institute of Technology, Italy <i>Room: Aula Magna</i>		
	Aula Magna	Aula Riviste	Aula Periodici
10:30 - 12:10	Session 4.1 - Special Session #1: Navigation, georeferenced spatial data acquisition and analysis in precision agriculture	Session 4.2 - Special Session #16: Measurement of soil water erosion at different spatial scales	Session 4.3 - Special Session #17: Measurements for risk management in agriculture
12:10 - 13:00	COFFEE BREAK + POSTER SESSION		
13:00 - 14:00	LUNCH		
14:00 - 15:00	TUTORIAL + DEMO Autonomous Mobile Robots for Crop Monitoring Prof. Gabriele Costante, <i>University of Perugia, Italy</i> <i>Room: Aula Magna</i>		
15:00 - 15:20	CLOSING AND AWARD CEREMONY <i>Room: Aula Magna</i>		



Technical Program - Thursday, November 3

13:00 - 18:00

REGISTRATION

Room: San Pietro Abbey

14:00 - 14:30

OPENING SESSION - WELCOME ADDRESSES

Prof. Maurizio Oliviero, *Rector of the University of Perugia, Italy*

Prof. Francesca Todisco, *University of Perugia, Italy*

Room: San Pietro Abbey - Aula Magna

14:30 - 15:30

PLENARY SESSION

Room: San Pietro Abbey - Aula Magna

Chair: Prof. Franco Famiani, *University of Perugia, Italy*

Canopy-cooling systems applied on fruit trees for climate change adaptation

Prof. Arnon Dag, *Agricultural Research Organization, Volcani Center Ministry of Agriculture, Israel*

15:30 - 15:50

COFFEE BREAK

Room: San Pietro Abbey

15:50 - 17:30

Session 1.1 - ICT application in the energy, industrial and biorefineries chains based on wood and lignocellulosic biomass

Room: San Pietro Abbey - Aula Magna

Chair: Giuseppe Toscano, *Università Politecnica delle Marche, Italy*

15:50 *Performance evaluation of a benchtop wood pellet length analyser based on visual imaging*

Giuseppe Toscano (Università Politecnica delle Marche), Chiara Masci (Metacortex srl), Rino Goller (Metacortex srl), Sara Di Stefano (Università Politecnica delle Marche), Michele Naspi (Università Politecnica delle Marche) and Thomas Gasperini (Università Politecnica delle Marche).

16:10 *Assessment of energy content of industrial woodchip based on prediction models of moisture content using portable NIR spectrophotometer*

Elena Leoni (Università Politecnica delle Marche), Manuela Mancini (Università Politecnica delle Marche), Sara Fabrizi (Università Politecnica delle Marche), Carmine de Francesco (Università Politecnica delle Marche), Gianni Picchi (CNR-IBE (Sesto Fiorentino)) and Giuseppe Toscano (Università Politecnica delle Marche).

16:30 *An innovative retrofitting solution for the reduction of particulate matter in small sized pellet stoves*

Valentina Coccia (University of Perugia CIRIAF/CRB), Franco Cotana (University of Perugia CIRIAF/CRB), Ramoon Barros Lovate Temporum (University of Perugia CIRIAF/CRB) and Leandro Lunghi (University of Perugia CIRIAF/CRB).

16:50 *Wood pellet bulk density determination by machine vision deep learning technique*

Giuseppe Toscano (Department of Agricultural, Food and Environmental Sciences (D3A), Università Politecnica delle Marche (UNIVPM)), Roberto Pierdicca (Department of Civil, Building and Architectural Engineering (DICEA), Università Politecnica delle Marche (UNIVPM)), Thomas Gasperini (Department of Agricultural, Food and Environmental Sciences (D3A), Università Politecnica delle Marche (UNIVPM)), Andrea Felicetti (Department of Information Engineering (DII), Università Politecnica delle Marche (UNIVPM)), Giorgio Rossini (Department of Agricultural, Food and Environmental Sciences (D3A), Università Politecnica delle Marche (UNIVPM)) and Mattia Balestra (Department of Agricultural, Food and Environmental Sciences (D3A), Università Politecnica delle Marche (UNIVPM)).

17:10 *Energy characterization of wood briquettes and possible use in automated domestic heating systems*

Alessio Mencarelli (Università degli Studi di Padova), Raffaele Cavalli (Università degli Studi di Padova) and Rosa Greco (Università degli Studi di Padova).



15:50 - 17:10

Session 1.2 - Gaseous emissions in livestock production: advances in measurement and modelling from barn to the field

Room: San Pietro Abbey - Aula Riviste

Chairs: Stefania Pindozi, University of Naples Federico II, Italy

Alberto Finzi, University of Milan, Italy

Marco Bovo, University of Bologna, Italy

Elio Dinuccio, University of Turin, Italy

15:50 *Monitoring and Analysis of the Gaseous Emissions Collected in a Livestock Farm*

Enrica Santolini (DISTAL - ALMA MATER STUDIORUM UNIVERSITA' DI BOLOGNA), Marco Bovo (DISTAL - ALMA MATER STUDIORUM UNIVERSITA' DI BOLOGNA), Alberto Barbaresi (DISTAL - ALMA MATER STUDIORUM UNIVERSITA' DI BOLOGNA), Miki Agrusti (DISTAL - ALMA MATER STUDIORUM UNIVERSITA' DI BOLOGNA), Patrizia Tassinari (DISTAL - ALMA MATER STUDIORUM UNIVERSITA' DI BOLOGNA), Andrea Pezzuolo (University of Padova) and Daniele Torreggiani (DISTAL - ALMA MATER STUDIORUM UNIVERSITA' DI BOLOGNA).

16:10 *Development and evaluation of an in vitro procedure to assess enteric methane production*

Flavia Dela Pierre (DISAFA, Department of Agricultural, Forest and Food Sciences, University of Turin), Martina Friuli (DISAFA, Department of Agricultural, Forest and Food Sciences, University of Turin), Luca Rollé (DISAFA, Department of Agricultural, Forest and Food Sciences, University of Turin), Riccardo Fortina (DISAFA, Department of Agricultural, Forest and Food Sciences, University of Turin), Sonia Tassone (DISAFA, Department of Agricultural, Forest and Food Sciences, University of Turin) and Elio Dinuccio (DISAFA, Department of Agricultural, Forest and Food Sciences, University of Turin).

16:30 *Treatment of dairy cattle slurry for biogas production and nitrogen recovery*

Ester Scotto di Pertà (University of Naples Federico II), Raffaele Grieco (University of Naples Federico II), Stefano Papirio (University of Naples Federico II), Giovanni Esposito (University of Naples Federico II), Elena Cervelli (University of Naples Federico II) and Stefania Pindozi (University of Naples Federico II).

16:50 *Biochar covering to mitigate the ammonia emissions from the manure storage tank: Effect of the pyrolysis temperature*

Ester Scotto di Pertà (University of Naples Federico II), Paola Giudicianni (Institute of Sciences and Technologies for Sustainable Energy and Mobility - C.N.R, Naples, Italy), Corinna Maria Grottola (Institute of Sciences and Technologies for Sustainable Energy and Mobility - C.N.R, Naples, Italy), Antonio Mautone (University of Naples Federico II), Elena Cervelli (University of Naples Federico II), Raffaele Ragucci (Institute of Sciences and Technologies for Sustainable Energy and Mobility - C.N.R, Naples, Italy) and Stefania Pindozi (University of Naples Federico II).

15:50 - 17:30

Session 1.3 - New advancements and integrations of observation systems for monitoring hydrological processes and for supporting the sustainable management of agro-forest systems

Room: San Pietro Abbey - Aula Periodici

Chairs: Gabriele Baroni, *University of Bologna, Italy*

Arianna Facchi, *Università degli Studi di Milano, Italy*

Christian Massari, *National Research Council, Italy*

Andrea Merlone, *Istituto Nazionale di Ricerca Metrologica, Italy*

15:50 *Comparison of cosmic-ray neutron sensing and gamma-ray spectrometry for non-invasive soil moisture estimation over a large cropped field*

Stefano Gianessi (Department of Agricultural and Food Sciences (DISTAL) Alma Mater Studiorum – University of Bologna), Matteo Polo (FINAPP s.r.l.), Luca Stevanato (FINAPP s.r.l.), Marcello Lunardon (Department of Physics and Astronomy University of Padova) and Gabriele Baroni (Department of Agricultural and Food Sciences (DISTAL) University of Bologna).

16:10 *Comparison between a rigid and flexible border irrigation scheduling: a pilot case study in Northern Italy*

Fabiola Gangi (Università di Milano), Claudio Gandolfi (Università di Milano) and Daniele Masseroni (Università di Milano).

16:30 *Improving Cosmic-Ray Neutron Sensing with Neutron Spectrometry*

Andrea Cirillo (Politecnico di Milano), Marco Caresana (Politecnico di Milano), Giacomo Paolo Manessi (Else Nuclear S.r.l.) and Massimiliano Clemenza (Istituto Nazionale di Fisica Nucleare - Sezione Milano Bicocca).

16:50 *Use of satellite-based phenometrics, geophysical soil data and a semi-distributed agro-hydrological model for variable-rate irrigation management in a maize farm in northern Italy*

Alice Mayer (University of Milano), Bianca Ortuani (University of Milano), Margherita De Peppo (National Research Council), Francesco Nutini (National Research Council), Alberto Crema (National Research Council), Giorgio Ragagnoli (University of Milano) and Arianna Facchi (University of Milano).

17:10 *A customizable and user friendly R package to process big data from the Tree Talker system*

Jerzy Piotr Kabala (University of Campania "Luigi Vanvitelli"), Francesco Niccoli (University of Campania "Luigi Vanvitelli") and Giovanna Battipaglia (University of Campania "Luigi Vanvitelli").



17:30 - 18:10

TUTORIAL SESSION

Room: San Pietro Abbey - Aula Magna

Chair: Prof. Francesca Todisco, *University of Perugia, Italy*

Advanced remote sensing techniques to monitor steep-slope viticulture under climate change scenarios

Prof. Paolo Tarolli, *University of Padua, Italy*

19:00

WELCOME PARTY

Restaurant Collins' @ Hotel Sina Brufani

Piazza Italia, 12



Technical Program - Friday, November 4

08:30 - 17:00

REGISTRATION

Room: San Pietro Abbey

09:00 - 10:00

PLENARY SESSION

Room: San Pietro Abbey - Aula Magna

Chair: Prof. Francesco Tei, *University of Perugia, Italy*

Smart Plant Cultivation for Space Exploration: Goals and Challenges

Prof. Stefania De Pascale, *University of Naples Federico II, Italy*

10:00 - 11:20

ROUND TABLE

Room: San Pietro Abbey - Aula Magna

Round Table on the project PNRR **Agritech - SPOKE 3**, *Enabling technologies and sustainable strategies for the smart management of agricultural systems and their environmental impact*, with the participation of Prof. *Gabriele Cruciani*, Delegato per il settore terza missione, University of Perugia; Prof. *Daniele Porena*, Delegato per il settore Riforme, semplificazione e supporto legale, University of Perugia; Prof. *Luca Corelli Grappedelli*, Coordinator PNRR Agritech - SPOKE 3, University of Bologna; Prof. *Francesco Tei*, Coordinator DSA3 PNRR Agritech - SPOKE 3, University of Perugia.

11:20 - 11:40

COFFEE BREAK

Room: San Pietro Abbey

11:40 - 13:20

Session 2.1 - General Session

Room: San Pietro Abbey - Aula Magna

Chair: Prof. Pietro Goglio, *University of Perugia, Italy*

11:40 *A smart sensing system for the drying process of figs*

Marco Carratù (University of Salerno), Daniele Buonocore (University of Salerno), Giuseppe Ciavolino (University of Salerno), Domenico Di Caro (University of Salerno), Consolatina Liguori (University of Salerno) and Antonio Pietrosanto (University of Salerno).

12:00 *Data-Driven Model Predictive Control for Skid-Steering Unmanned Ground Vehicles*

Lorenzo Gentilini (University of Bologna), Dario Mengoli (University of Bologna), Simone Rossi (University of Bologna) and Lorenzo Marconi (University of Bologna).

12:20 *On-line real-time fruit size estimation using a depth-camera sensor*

Dario Mengoli (University of Bologna), Gianmarco Bortolotti (DISTAL - Alma Mater Studiorum - Università di Bologna), Mirko Piani (DISTAL - Alma Mater Studiorum - Università di Bologna) and Luigi Manfrini (DISTAL - Alma Mater Studiorum - Università di Bologna).

12:40 *Assessment of Ultra Wide Band device for monitoring chicken behaviour reared free-range*

Alice Cartoni Mancinelli (Dpt. Scienze Agrarie Alimentari e Ambientali - Università degli studi di Perugia Perugia), Diletta Chiattelli (Dpt. Scienze Agrarie Alimentari e Ambientali - Università degli studi di Perugia Perugia), Luca Roselli (Università degli studi di Perugia), Gianmaria Bernacchia (Luna Geber Engineering srl – Spin-off Università degli studi di Perugia), Costanza Nicconi (Luna Geber Engineering srl – Spin-off Università degli studi di Perugia), Jacopo Torroni (Luna Geber Engineering srl – Spin-off Università degli studi di Perugia) and Cesare Castellini (Dpt. Scienze Agrarie Alimentari e Ambientali - Università degli studi di Perugia Perugia).

13:00 *UAV in precision agriculture: a preliminary assessment of uncertainty for vegetation health index*

Pasquale Daponte (University of Sannio), Luca De Vito (University of Sannio), Fatemeh Khalesi (University of Sannio), Francesco Picariello (University of Sannio), Ioan Tudosa (University of Sannio).

11:40 - 13:20

Session 2.2 - Digital technologies in agricultural, livestock and food-processing facilities

Room: San Pietro Abbey - Aula Riviste

Chairs: Andrea Pezzuolo, *University of Padova, Italy*

Carlo Bibbiani, *University of Pisa, Italy*

Alberto Barbaresi, *University of Bologna, Italy*

11:40 *Potentials for Technological Advancement in Anaerobic Digestion Plants: a Multicriteria Analysis*

Giovanni Ferrari (University of Padova), Guo Hao (China Agricultural University), Marco Sozzi (University of Padova), Zihao Zheng (Guangzhou University), Francesco Marinello (University of Padova) and Andrea Pezzuolo (University of Padova).

12:00 *Sensorization of an electric dryer for Bombyx mori (L.) silken cocoons desiccation*

Domenico Giora (University of Padova - Department of Land, Environment, Agriculture and Forestry), Alberto Assirelli (CREA-Council for Agricultural Research and Economics Research Center for Engineering and Agro-Food Processing), Silvia Cappellozza (CREA-Council for Agricultural Research and Economics Sericulture Laboratory of Padua), Alessio Saviane (CREA-Council for Agricultural Research and Economics Sericulture Laboratory of Padua), Francesco Marinello (University of Padova - Department of Land, Environment, Agriculture and Forestry) and Luigi Sartori (University of Padova - Department of Land, Environment, Agriculture and Forestry).

12:20 *An IoT based Weather Monitoring System for Smart Agriculture*

Hassan Ali (University of Doha for Science and Technology (UDST)), Aitazaz Farooque (University of Prince Edward Island), Farhat Abbas (University of Doha for Science and Technology (UDST)), Raziq Yaqoob (Alabama A&M University), Ahmed Abdalla (University of Doha for Science and Technology (UDST)) and Permjit Soora (University of Doha for Science and Technology (UDST)).

12:40 *Validation campaign of a smart dynamic scale for measuring live-fish biomass in aquaculture*

Lorenzo Rossi (Department of Veterinary Sciences - University of Pisa), Carlo Bibbiani (Department of Veterinary Sciences - University of Pisa), Baldassare Fronte (Department of Veterinary Sciences - University of Pisa), Eugenio Damiano (MEGA Materials s.r.l.) and Alberto Di Lieto (Department of Physics - University of Pisa).

13:00 *Simulations in agricultural buildings: a machine learning approach to forecast seasonal energy need*

Mattia Ceccarelli (University of Bologna), Alberto Barbaresi (University of Bologna), Giulia Menichetti (Harvard Medical School), Enrica Santolini (University of Bologna), Marco Bovo (DICAM Department - University of Bologna), Patrizia Tassinari (University of Bologna), Francesco Barreca (University of Reggio Calabria) and Daniele Torreggiani (University of Bologna).

11:40 - 13:20

Session 2.3 - Artificial intelligence, innovative data analysis and big data for agriculture and food applications

Room: San Pietro Abbey - Aula Periodici

Chairs: Marco Sozzi, University of Padova, Italy

Riccardo Dainelli, National Research Council, Italy

11:40 *Geostatistical analysis of downy mildew (*Plasmopara viticola*) symptoms on grapevines leaves*

Marco Sozzi (University of Padova), Alessandro Zanchin (University of Padova), Giovanni Ferrari (University of Padova), Alessia Cogato (University of Udine), Luigi Sartori (University of Padova) and Francesco Marinello (University of Padova).

12:00 Variational Autoencoder for Early Stress Detection in Smart Agriculture: A Pilot Study

Alberto Zancanaro (University of Padova), Giulia Cisotto (University of Padua), Dagmawi Tegegn (University of Milan-Bicocca), Leonardo Badia (University of Padova), Sara Lucia Manzoni (University of Milan-Bicocca), Ivan Reguzzoni (SeleTech Engineering Srl), Edoardo Lotti (SeleTech Engineering Srl) and Italo Zoppis (University of Milan-Bicocca).

12:20 On the impact of the stem electrical impedance in neural network algorithms for plant monitoring applications

Mattia Barezzi (Politecnico di Torino), Federico Cum (Politecnico di Torino), Umberto Garlando (Politecnico di Torino), Maurizio Martina (Politecnico di Torino) and Danilo Demarchi (Politecnico di Torino).

12:40 Preliminary spray nozzle characterization activities through shadowgraphy at the AgroForestry Innovation Lab (AFI-Lab)

Lorenzo Becce (Free University of Bolzano-Bozen), Saba Amin (Free University of Bolzano-Bozen), Giovanni Carabin (Free University of Bolzano-Bozen) and Fabrizio Mazzetto (Free University of Bolzano-Bozen).

13:00 Clustering of Remotely Sensed Time Series using Functional Principal Component Analysis to Monitor Crops

Luca Coviello (University of Trento, DISI), Francesco Maria Martini (Università Politecnica delle Marche, D3A), Lorenzo Cesaretti (CREA, Centro di ricerca Foreste e Legno Arezzo), Simone Pesaresi (Università Politecnica delle Marche, D3A), Francesco Solfanelli (Università Politecnica delle Marche, D3A) and Adriano Mancini (Università Politecnica delle Marche, DII).

13:20 - 14:30

LUNCH

Room: San Pietro Abbey

14:30 - 16:30

Session 3.1 - Platforms for integrated analyses of agro-ecosystems

Room: San Pietro Abbey - Aula Magna

Chairs: Marco Bindi, *University of Florence, Italy*

Elena Paoletti, *National Research Council, Italy*

14:30 The Nitrate fate tool for the assessment of the groundwater vulnerability within the geospatial decision support system LandSupport

Marialaura Bancheri (Institute for Mediterranean Agricultural and Forestry Systems (ISAFOM), CNR), Giuliano Langella (Department of Agriculture, University of Napoli Federico II, Portici, Naples, Italy), Piero Manna (Institute for Mediterranean Agricultural and Forestry Systems (ISAFOM), CNR, Portici, NA, Italy), Nadia Orefice (Institute for Mediterranean Agricultural and Forestry Systems (ISAFOM), CNR, Portici, NA, Italy), Antonietta Agrillo (Institute for Mediterranean Agricultural and Forestry Systems (ISAFOM), CNR, Portici, NA, Italy), Giuliano Ferraro (CRISP Research Center, Department of Agriculture, University of Napoli Federico II, Portici, Naples, Italy), Alessia Perego (University of Milano, Department of Plant Production, Milano, Italy) and Angelo Basile (Institute for Mediterranean Agricultural and Forestry Systems (ISAFOM), CNR, Portici, NA, Italy).

14:50 Preliminary results of a novel approach to assess the fundamental sway frequency of trees

Francesco Zanotto (Università degli studi di Padova), Luca Marchi (Università degli studi di Padova) and Stefano Grigolato (Università degli studi di Padova).

15:10 Enhancement of Vision-Based 3D Reconstruction Systems Using Radar for Smart Farming

Lukas Meyer (Friedrich-Alexander-Universität Erlangen Nürnberg), Jonas Gedschold (TU Ilmenau), Tim-Erich Wegner (TU Ilmenau), Giovanni Del Galdo (TU Ilmenau) and Adam Kalisz (Friedrich-Alexander-Universität Erlangen Nürnberg).

15:30 Assessing the potential for forest residue classification and distribution over clear felled areas using UAVs and Machine Learning: a preliminary case study in South Africa

Alberto Udali (Dipartimento TESAF, Università di Padova), Bruce Talbot (Department of Forest and Wood Science-Faculty of Agrisciences Stellenbosch University), Stefano Puliti (Division of Forest and Forest Resources - Norwegian Institute for Bioeconomy Research (NIBIO)), Jacob Crous (Sappi Forests, Shaw Research Centre), Emanuele Lingua (Dipartimento TESAF, Università di Padova) and Stefano Grigolato (Dipartimento TESAF, Università di Padova).

15:50 Cost-effective tracing techniques for the rapid characterization of spray deposition and drift through electrical conductivity and fluorescence

Antonio Altana (Faculty of science and technology Free University of Bozen), Lorenzo Becce (Competence Centre for Plant Health Free University of Bozen), Enrico Avancini (Faculty of science and technology Free University of Bozen), Paolo Lugli (Free University of Bozen), Luisa Petti (Faculty of science and technology & Competence Centre for Plant Health Free University of Bozen) and Fabrizio Mazzetto (Faculty of science and technology & Competence Centre for Plant Health Free University of Bozen).

16:10 Sugarcane responses to elevated ozone

Barbara Baesso Moura (Institute of Research on Terrestrial Ecosystems (IRET) National Research Council of Italy (CNR)), Yasutomo Hoshika (Institute of Research on Terrestrial Ecosystems (IRET) National Research Council of Italy (CNR)), Rafael Vasconcelos Ribeiro (Department of Plant Biology, Institute of Biology University of Campinas (UNICAMP) Campinas, Brazil) and Elena Paoletti (Institute of Research on Terrestrial Ecosystems (IRET) National Research Council of Italy (CNR)).

14:30 - 16:30

Session 3.2 - Precision horticulture

Room: San Pietro Abbey - Aula Riviste

Chairs: Manuela Zude-Sasse, *Leibniz Institute for Agricultural Engineering and Bioeconomy*

Lav R. Khot, *Washington State University, USA*

Luigi Manfrini, *Università di Bologna, Italy*

Gianmarco Bortolotti, *Università di Bologna, Italy*

14:30 *Effect of cell size on mechanics of strawberry fruit tissue*

Xue An (Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB)), Zhiguo Li (Northwest Agricultural and Forest University) and Manuela Zude-Sasse (Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB)).

14:50 *A computer vision system for in-field fruit quality evaluation: preliminary results on peach fruit*

Gianmarco Bortolotti (DISTAL - Alma Mater Studiorum - Università di Bologna), Dario Mengoli (DEI - Alma Mater Studiorum - Università di Bologna), Mirko Piani (DISTAL - Alma Mater Studiorum - Università di Bologna), Luca Corelli Grappadelli (DISTAL - Alma Mater Studiorum - Università di Bologna) and Luigi Manfrini (DISTAL - Alma Mater Studiorum - Università di Bologna).

15:10 *Reliable image processing algorithm for sunburn management in green apples*

Basavaraj Amogi (Washington State University), Rakesh Ranjan (The Conservation Fund, Freshwater Institute) and Lav Khot (Washington State University).

15:30 *Quantification of Modern Apple Orchard Effects on Meteorological Variables*

Karisma Yumnam (Department of Biological Systems Engineering, Washington State University, Prosser, Washington, United States), Matthew D. Cann (AgWeatherNet, Washington State University, Prosser, Washington, United States), Lav R. Khot (Department of Biological Systems Engineering, Washington State University Prosser, Washington, United States), David J. Brown (METER Group, Pullman, Washington, United States), Joseph Boomgard-Zagrodnik (AgWeatherNet, Washington State University, Prosser, Washington, United States) and Lee Kalcsits (Department of Horticulture, Washington State University, Pullman, Washington, United States).

15:50 *Fourier analysis of LiDAR scanned 3D point cloud data for surface reconstruction and fruit size estimation*

Nicolas Tapia Zapata (Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB)), Kowshik Kumar Saha (Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB)), Nikos Tsoulas (Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB)) and Manuela Zude-Sasse (Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB)).

16:10 *Aerial-RGB imagery based 3D canopy reconstruction and mapping of grapevines for precision management*

Giacomo Tolomelli (University of Bologna), Gajanan Suryakant Kothawade (Washington State University), Abhilash Kumar Chandel (Virginia Tech), Luigi Manfrini (University of Bologna), Pete Jacoby (Washington State University) and Lav R. Khot (Washington State University).

14:30 - 16:30

Session 3.3 - Contactless measurements, edge computing and computer vision for agriculture, forestry and zootechnics

Room: San Pietro Abbey - Aula Periodici

Chair: Loris Francesco Termite, *Idea-Re S.r.l.*

14:30 *Introducing on-the-go sensing rover for vines canopy abiotic stressors detection*

Simone Pasinetti (University of Brescia), Mauro Maesano (University of Tuscia), Elena Brunori (University of Tuscia), Federico Valerio Moresi (University of Tuscia), Alessandra Bernardini (University of Tuscia), Paolo Cirenei (Bedurin Srl) and Rita Biasi (University of Tuscia).

14:50 *Innovation in olive-growing by Proximal sensing LiDAR for tree volume estimation*

Stefano Chiappini (Department of Agricultural, Food, and Environmental Sciences Marche Polytechnic University Ancona, Italy), Veronica Giorgi (Department of Agricultural, Food, and Environmental Sciences Marche Polytechnic University Ancona, Italy), Davide Neri (Department of Agricultural, Food, and Environmental Sciences Marche Polytechnic University Ancona, Italy), Andrea Galli (Department of Agricultural, Food, and Environmental Sciences Marche Polytechnic University Ancona, Italy), Ernesto Marcheggiani (KU Leuven), Eva Savina Malinverni (Department of Construction, Civil Engineering and Architecture Marche Polytechnic University), Roberto Pierdicca (Department of Construction, Civil Engineering and Architecture Marche Polytechnic University) and Mattia Balestra (Department of Agricultural, Food, and Environmental Sciences Marche Polytechnic University Ancona, Italy).

15:10 *Assessment of the geometrical characteristics of hazelnut intensive orchard by an Unmanned Aerial Vehicle (UAV)*

Alessandra Vinci (Department of Agricultural, Food and Environmental Sciences - University of Perugia), Chiara Traini (Department of Agricultural, Food and Environmental Sciences - University of Perugia), Daniela Farinelli (Department of Agricultural, Food and Environmental Sciences - University of Perugia) and Raffaella Brigante (Independent Researcher).

15:30 *Non-invasive measuremets for characterization of *Hermetia Illucens* (BSF) life cycle in rearing plant*

Massimiliano Proietti (Idea-re S.r.l.), Andrea Marini (Idea-re S.r.l. Perugia, Italy), Alberto Garinei (Department of Engineering Sciences, Guglielmo Marconi University, Rome Italy Idea-Re S.r.l. Perugia, Italy), Gianluca Rossi (Department of Engineering Università degli Studi di Perugia), Federico Bianchi (Idea-re S.r.l. Perugia, Italy), Marcello Marconi (Department of Engineering Sciences, Guglielmo Marconi University, Rome Italy Idea-Re S.r.l. Perugia, Italy), Silvia Discepolo (Dipartimento di Ingegneria Industriale e Scienze Matematica (DIISM), Università Politecnica delle Marche Ancona, Italy), Maria Teresa Calcagni (Dipartimento di Ingegneria Industriale e Scienze Matematica (DIISM), Università Politecnica delle Marche Ancona, Italy), Paolo Castellini (Dipartimento di Ingegneria Industriale e Scienze Matematica (DIISM), Università Politecnica delle Marche Ancona, Italy), Milena Martarelli (Dipartimento di Ingegneria Industriale e Scienze Matematica (DIISM), Università Politecnica delle Marche Ancona, Italy), Giacomo Zeni (BugsLife S.r.l., Bevagna (PG), Italy) and Stefano Speziali (Idea-re S.r.l. Perugia, Italy).

15:50 *A Discrimination of Healthy and Rotten Hazelnuts Using a THz Imaging Scanner*

Manuel Greco (Dipartimento di Scienze - Università degli Studi "Roma Tre"), Emilio Giovenale (ENEA, Fusion and Nuclear Dept.), Fabio Leccese (Università degli Studi "Roma Tre") and Andrea Doria (ENEA, Fusion and Nuclear Dept.).

16:10 *Development of a monitoring system to assess honeybee colony health*

Massimiliano Micheli (University of Brescia), Simone Pasinetti (University of Brescia), Matteo Lancini (University of Brescia) and Gabriele Coffetti (University of Brescia).



16:30 - 16:50

COFFEE BREAK

Room: San Pietro Abbey

16:50 - 17:30

TUTORIAL SESSION

Room: San Pietro Abbey - Aula Magna

Chair: Prof. Marco Vizzari, *University of Perugia, Italy*

Digital image processing algorithms and concrete application

Prof. Gianluca Vinti, *University of Perugia, Italy*

20:00

GALA DINNER

Ristorante Del Sole

Via della Rupe, 1 - Perugia



Technical Program - Saturday, November 5

09:00 - 13:00

REGISTRATION

Room: San Pietro Abbey

09:30 - 10:30

PLENARY SESSION

Room: San Pietro Abbey - Aula Magna

Chair: Prof. Giovanni Carabin, *University of Bolzano, Italy*

From Nature to Nature through Robotics

Emanuela Del Dottore, PhD, *Italian Institute of Technology, Italy*

10:30 - 12:10

Session 4.1 - Navigation, georeferenced spatial data acquisition and analysis in precision agriculture

Room: San Pietro Abbey - Aula Magna

Chairs: Andrea Masiero, *University of Florence, Italy*

Fabio Radicioni, *University of Perugia, Italy*

Aurelio Stoppini, *University of Perugia, Italy*

10:30 *How important is UAVs RTK accuracy for the identification of certain vine diseases?*

Fabio Zottele (Fondazione Edmund Mach), Paolo Crocetta (Green Fly) and Valerio Baiocchi (Sapienza University of Rome).

10:50 *Towards the use of low-cost GNSS receivers for permanent networks in precision agriculture*

Paolo Dabove (Politecnico di Torino) and Vincenzo Di Pietra (Politecnico di Torino).

11:10 *Thermal camera geometric self-calibration supported by RTK measurements*

Erica Parisi (University of Florence), Irene Cortesi (University of Florence), Andrea Masiero (University of Florence), Francesco Mugnai (University of Florence) and Grazia Tucci (University of Florence).

11:30 *A low-cost multi-GNSS PPP-RTK solution for precision agriculture: a preliminary test*

Umberto Robustelli (Department of Engineering, University of Naples Parthenope), Matteo Cutugno (Department of Civil, Architectural and Environmental Engineering, University of Naples Federico II) and Giovanni Pugliano (Department of Civil, Architectural and Environmental Engineering, University of Naples Federico II).

11:50 *Multi-constellation Network RTK for Automatic Guidance in Precision Agriculture*

Fabio Radicioni (Engineering Dept. University of Perugia), Aurelio Stoppini (Engineering Dept. University of Perugia), Grazia Tosi (Engineering Dept. University of Perugia) and Laura Marconi (Engineering Dept. University of Perugia).

10:30 - 12:10

Session 4.2 - Measurement of soil water erosion at different spatial scales

Room: San Pietro Abbey - Aula Riviste

Chairs: Lorenzo Vergni, *University of Perugia, Italy*

Vincenzo Pampalone, *University of Palermo, Italy*

Giovanni Francesco Ricci, *University of Bari, Italy*

10:30 *Effects of different forest recovery management on runoff and soil erosion in an area affected by Vaia storm*

Andrea Andreoli (Faculty of Science and Technology, Free University of Bozen-Bolzano), Alessio Rozzoni (Faculty of Science and Technology, Free University of Bozen-Bolzano), Enrico Tomelleri (Faculty of Science and Technology, Free University of Bozen-Bolzano) and Francesco Comiti (Faculty of Science and Technology, Free University of Bozen-Bolzano).

10:47 *Measuring the USLE soil erodibility factor in the unit plots of Sparacia (southern Italy) experimental area*

Vincenzo Bagarello (University of Palermo), Vito Ferro (University of Palermo) and Vincenzo Pampalone (University of Palermo).

11:04 *Monitoring suspended sediment transport in two mountainous river basins: the Carapelle and the Celone (Apulia, Italy)*

Giovanni Francesco Ricci (University of Bari), Anna Maria De Girolamo (Water Research Institute, National Research Council, Bari, Italy) and Francesco Gentile (University of Bari).

11:21 *Evaluation of the GPM IMERG half-hourly final precipitation product in the quantification of rainfall erosivity in central Italy*

Lorenzo Vergni (Department of Agricultural Food and Environmental Sciences), Andrea Parisi (Department of Agricultural Food and Environmental Sciences) and Francesca Todisco (Department of Agricultural Food and Environmental Sciences).

11:38 *Theoretical advancements on a recently proposed method to measure rainfall energy*

Francesco Giuseppe Carollo (University of Palermo), Vito Ferro (University of Palermo), Vincenzo Palmeri (University of Palermo), Vincenzo Pampalone (University of Palermo) and Alessio Nicosia (University of Palermo).

11:55 *Viticulture and Cultural Landscapes: remote sensing and Earth surface processes modelling to promote sustainable agricultural practices*

Eugenio Straffellini (Università degli Studi di Padova, Land, Environment, Agriculture and Forestry, University of Padova) and Paolo Tarolli (Università degli Studi di Padova, Land, Environment, Agriculture and Forestry, University of Padova).

10:30 - 11:50

Session 4.3 - Measurements for risk management in agriculture

Room: San Pietro Abbey - Aula Periodici

Chairs: Alberto Garinei, *Università degli Studi Guglielmo Marconi, Italy*
Simone Severini, *Tuscia University, Italy*

10:30 *How data monitoring and crop modelling can support agricultural risk management solutions in climate change scenarios?*

Samuele Trestini (Università degli Studi di Padova), Francesco Morari (Università degli Studi di Padova), Francesco Pirotti (Università degli Studi di Padova) and Simone Severini (Università degli Studi della Tuscia).

10:50 *Benefits of using production factors in assessing farm risk: a simulation on the role of irrigation data*

Luigi Biagini (Università degli Studi della Tuscia), Cinzia Zinnanti (Università degli Studi della Tuscia) and Simone Severini (Università degli Studi della Tuscia).

11:10 *Snow water equivalent (SWE) measurements for better management of water resources to reduce drought risk*

Andrea Mangeruca (Arcadiasit s.r.l.), Gianluca Ferrari (Radarmeteo s.r.l.), Alberto Garinei (Department of Engineering Sciences, Guglielmo Marconi University, Idea-Re s.r.l.), Lucia Cisco (Hypermeteo s.r.l.), Maurizio Sozzi (Arcadiasit s.r.l.), Marcello Marconi (Department of Engineering Sciences, Guglielmo Marconi University, Idea-Re s.r.l.), Massimo Crespi (Radarmeteo s.r.l.), Andrea Chini (Radarmeteo s.r.l.), Emanuele Piccioni (Idea-Re s.r.l.), Davide Bavera (Arcadiasit s.r.l.) and Giorgio Frigerio (Arcadiasit s.r.l.).

11:30 *(Extreme) Weather index-based insurances: data, models and other aspects we need to think about*

Marco Tappi (University of Foggia) and Fabio Gaetano Santeramo (University of Foggia).

12:10 - 13:00

POSTER SESSION

Room: San Pietro Abbey - Aula Magna

Chair: Lorenzo Vergni, *University of Perugia, Italy*

PS-1 *The efficiency of Digestate as Inoculum for in vitro Digestibility of Feeds*

Sara Glorio Patrucco (DISAFA - Dep. of Agricultural, Forestry and Food Science), Riccardo Fortina (DISAFA - Dep. of Agricultural, Forestry and Food Science), Elio Dinuccio (DISAFA - Dep. of Agricultural, Forestry and Food Science), Flavia Dela Pierre (DISAFA - Dep. of Agricultural, Forestry and Food Science) and Sonia Tassone (DISAFA - Dep. of Agricultural, Forestry and Food Science).

PS-2 *Soil Moisture and EC Sensor Design and Testing with Different Types of Soil for Salinity Assessment*

Vamsee Krishna Bodasingi (Indian Institute of Technology Bombay), Bakul Rao (Indian Institute of Technology Bombay) and Harish K. Pillai (Indian Institute of Technology Bombay).

PS-3 *Sustainable olive oil supply chain for climate change mitigation*

Luca Regni (University of Perugia) and Primo Proietti (University of Perugia).

PS-4 *Analytical Evaluation of Age of Information in Networks of Correlated Sources*

Laura Crosara (University of Padova), Alberto Zancanaro (University of Padova), Giulia Cisotto (University of Milano-Bicocca), Nicola Laurenti (University of Padova) and Leonardo Badia (University of Padova).

PS-5 *In vitro culture techniques in the plant germplasm safeguard for a sustainable agricultural development*

Luca Regni (University of Perugia), Simona Lucia Facchin (University of Perugia), Primo Proietti (University of Perugia) and Maurizio Micheli (University of Perugia).

PS-6 *Theoretical prediction of rainfall intensity for a small rainfall simulator*

Martina Agosta (University of Palermo), Vincenzo Bagarello (University of Palermo), Gaetano Caltabellotta (University of Palermo), Francesco Giuseppe Carollo (University of Palermo), Girolamo Vaccaro (University of Palermo) and Vincenzo Pampalone (University of Palermo).

PS-7 *An Integrated Multi-Sensor System for Remote Bee Health Monitoring*

Francesco Bellino (Politecnico di Torino), Giovanna Turvani (Politecnico di Torino), Umberto Garlando (Politecnico di Torino) and Fabrizio Riente (Politecnico di Torino).

PS-8 *Construction of statistical shape model of real cattle and its application to body measurement*

Xinying Luo (China Agricultural University), Yihu Hu (China Agricultural University), Zicheng Gao (China Agricultural University), Battsetseg Damjin (Research and development center of food, agriculture and light industry), Hao Guo (China Agricultural University), Alexey Ruchay (Federal Research Centre of Biological Systems and Agro-technologies of the Russian Academy of Sciences) and Andrea Pezzuolo (University of Padova).

PS-9 *Ion Mobility Spectrometry for Rapid HEMP Potency Testing - spectrometric testing of technical hemp*

Richard Marko (Slovak University of Technology in Bratislava Faculty of Informatics and Information Technologies), Martin Sabo (Slovak University of Technology in Bratislava Faculty of Informatics and Information Technologies), Katarina Valkovicova (Slovak University of Technology in Bratislava Faculty of Informatics and Information Technologies), Zuzana Gaborcikova (Slovak University of Technology in Bratislava Faculty of Informatics and Information Technologies), Rastislav Kavon (Slovak University of Technology in Bratislava Faculty of Informatics and Information Technologies), Matus Miklovic (Slovak University of Technology in Bratislava Faculty of Informatics and Information Technologies), Marek Janec (Slovak University of Technology in Bratislava Faculty of Informatics and Information Technologies), Peter Nemcek (Slovak University of Technology in Bratislava Faculty of Informatics and Information Technologies) and Filip Chalas (Slovak University of Technology in Bratislava Faculty of Informatics and Information Technologies).



PS-10 Primary Production Prediction from Aerial Spectrographic Survey

Giovanni Carabin (Free University of Bozen), Lorenzo Becce (Free University of Bozen), Andreas Mandler (Free University of Bozen) and Fabrizio Mazzetto (Free University of Bozen/Bolzano).

PS-11 Evaluation of remotely-sensed evapotranspiration datasets at different spatial and temporal scales at forest and grassland sites in Italy

Domenico De Santis (National Research Council), Concetta D'Amato (University of Trento), Paulina Bartkowiak (Eurac Research), Shima Azimi (University of Trento), Mariapina Castelli (Eurac Research), Riccardo Rigon (University of Trento) and Christian Massari (National Research Council).

PS-12 How water affects growing plants: an experimental set-up based on 2D vision and on-the-edge sensing

Simone Pasinetti (University of Brescia), Cristina Nuzzi (University of Brescia), Davide Botturi (University of Brescia), Gabriele Coffetti (University of Brescia), Sara Mangili (University of Brescia) and Manuel Collina (University of Brescia).

PS-13 Evaluation of the physiological and spectral responses of grapevines (*Vitis vinifera* L.) under different durations of drought stress under high temperature conditions

Alessia Cogato (University of Udine), Marco Sozzi (University of Padova), Franco Meggio (University of Padova), Francesco Marinello (University of Padova), Shaikh Jewan (University of Nottingham) and Vinay Pagay (University of Adelaide).

13:00 - 14:00

LUNCH

Room: San Pietro Abbey

14:00 - 15:00

TUTORIAL SESSION + LIVE DEMONSTRATION

Room: San Pietro Abbey - Aula Magna

Chair: Prof. Alessandra Vinci, *University of Perugia, Italy*

Autonomous Mobile Robots for Crop Monitoring

Prof. Gabriele Costante, *University of Perugia, Italy*

15:00 - 15:20

CLOSING AND AWARD CEREMONY

Room: San Pietro Abbey - Aula Magna
