MED 2021

29th Mediterranean Conference on Control and Automation

JUNE 22 – 25 2021, BARI, ITALY, http://med2021.poliba.it

Workshop Session at MED 2021
on
Control, Robotics, Sensing and Artificial Intelligence for Precision Agriculture

Abstract

Precision Agricolture (PA) is a modern farm management concept aimed at optimizing the overall agricultural production and its sustainability through *continuous* monitoring of the agricultural area and *local* intervention on it. To this aim, a variety of technologies are combined which range from remote sensing and proximal data collection to automation and robotics through Artificial Intelligence and Big Data. One of the main challenges that PA introduces is related to the high *variability* of the production activities. Such variability may result from a number of factors such as weather variables (temperature, precipitation, relative humidity, etc.), soil characteristics (texture, depth, nitrogen levels), cropping practices (till/no-till farming), weeds and diseases. Although farmers have always been aware of variability, the problem is that so far, they lacked the tools to measure, map and manage it precisely. In this regard, recent theoretical and technological advancements in the fields mentioned above represent a promising direction to cope with it and to build a comprehensive PA solution that can be effectively deployed on large-scale systems.

The workshop aims to give the research community a chance to: identify open research challenges for PA solutions, discuss possible research directions and solutions, foster new collaborations, and get a good overview of the state of the art from the invited talks.

Duration: Half day

Preferred mode of presentation (to be confirmed closer to the conference and depending on the pandemics evolution): Online

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List of topics

Schedule **13.00 – 17.00**:

Time	Topic
13.00 – 13.15	Opening
13.15 – 13.45	*Using active robotic vision techniques to deal with visual occlusions in robotic harvesting*, Chris Lehnert, Queensland University of Technology, Australia
13.45 – 14.15	*Monitoring and mapping of crop fields with UAV swarms*, Vito Trianni, Italian National Research Council, Italy
14.15 – 14.45	Coffee break – chatting all together
14.45 – 15.15	*Accuracy for off-road robots: A multi control approach for precision agriculture*, Roland Lenain, French National Research Institute for Agriculture, Food and Environment, France
15.15 – 15.45	*Remote Sensing and Data Analytics for Digital Agriculture – Challenges and Opportunities*, Sami Khanal, Ohio State University, USA
15.45 – 16.15	*Large-Scale Monitoring, Expert Input, and the Ecological Impact of Autonomy*, Ryan K. Williams, Virginia Polytechnic Institute and State University, USA
16.15 – 16.45	CFP Contributions / Round table
16.45 – 17.00	Closing

Details of the talks

1) **Title**: *Using active robotic vision techniques to deal with visual occlusions in robotic harvesting*
Abstract: In this presentation, I will discuss the potential for using active robotic vision methods to help deal with occlusions when autonomously harvesting crops in indoor protected cropping systems. In particular, I will outline a novel robotic vision method (3D Move to See) that aims at guiding a robots harvesting tool towards a target crop while maximizing its view of the crop and being efficient in time when executing the harvesting task. I will focus on robotic harvesting of indoor crops which offers an attractive solution to reducing labor costs while enabling future potential value through selective harvesting, optimizing crop quality, scheduling and therefore profit.
Speaker: Chris Lehnert, Queensland University of Technology, Australia
Bio: Dr. Chris Lehnert is a Robotics Lecturer within the Robotics and Autonomous Systems (RAS) discipline at QUT. His research interests lie in the development of novel methods for robotic manipulation in real world and challenging environments. A particular focus of his research has been on enabling robots to perform autonomous harvesting operations in horticulture. He led a small team of PhD students, post-doctoral fellows and engineers in developing new robotic technologies for horticulture through the Strategic Investment in Farm Robotics (SIFR) program at QUT. Chris completed his PhD in 2015 in learning robot control at QUT under the supervision of Centre Chief Investigator Professor Gordon Wyeth. His dissertation developed a learning control system that can adapt to the system model of an imprecisely manufactured robot to achieve high performance on a low-cost system.

2) **Title**: *Monitoring and mapping of crop fields with UAV swarms*

Abstract: Monitoring of crop fields to map features like weeds can be efficiently performed with unmanned aerial vehicles (UAVs) that, owing to their privileged perspective and motion speed, can cover large areas in a short time. However, the need for high-resolution images for precise classification of features (e.g., detecting even the smallest weeds in the field) contrasts with the limited payload and flight time that characterizes current UAVs, and requires several flights to uniformly cover a large field. However, the assumption that the whole field must be observed with the same precision is unnecessary when features are heterogeneously distributed, like weeds appearing in patches over the field. In this case, an adaptive approach that focuses only on relevant areas can perform better, especially when multiple UAVs are employed at the same time. Leveraging on a swarm-robotics approach, we propose a monitoring and mapping strategy that adaptively chooses the target areas based on the expected information gain, which measures the potential for uncertainty reduction due to further observations. The proposed strategy scales well with group size and overall leads to smaller mapping errors than uniform pre-planned monitoring approaches.

Speaker: Vito Trianni, Italian National Research Council, Italy

Bio: Vito Trianni received the M.Sc. degree in computer science engineering from the Politecnico di Milano, Italy, in 2000, the master's degree in information and communication technology from CEFRIEL, Italy, in 2001, and the Ph.D. degree in applied sciences from the Université Libre de Bruxelles, Belgium, in 2006. He is currently a permanent Researcher with the Institute of Cognitive Sciences and Technologies, National Research Council. His research mainly involves swarm intelligence and swarm robotics studies, with particular emphasis on the design and analysis of complex self-organizing systems and distributed cognitive processes. He pioneered the domain of Evolutionary Swarm Robotics. More recently, he is also conducting research on the analysis and design of large-scale decentralized systems, not limited to swarm robotics systems (e.g., cognitive radio networks, and cyber-physical and socio-technical systems).

3) **Title**: *Accuracy for off-road robots: A multi control approach for precision agriculture*

Abstract: The topic of accurate autonomous navigation has arisen as an important subject of research in recent years. Different control strategies have been developed to ensure a high level of precision, with satisfactory results in known and structured environments. In the framework of agriculture, the diversity of encountered situations and tasks to be achieved, associated with variable interaction conditions does not permit to use a single control approach to address satisfactorily a required high level of precision. As a result, this talk investigates several robotics behaviors to address such a variability allowing different kinds of robot to move in off-road areas, with a sufficient accuracy to achieve precision farming. The talk is illustrated with several examples, and will conclude with a discussion on the supervision, selection and tuning of these behaviors through task planning and on-line decision making.

Speaker: Roland Lenain, French National Research Institute for Agriculture, Food and Environment, France

Bio: Roland Lenain is currently research director at INRAE (French National Institute for Agriculture, Food and Environment) in the unit TSCF (Technology and Information Systems) at Clermont-Ferrand. He received a mechanical engineer degree from French institute for advanced mechanics in 2002. He obtained the same year a master's degree in mechanical and civil engineering. He defended is PhD in 2005 on the topic of automatic guidance of off-road mobile robots, at University Clermont-Auvergne (UCA). After completing a post-doctoral position in the department of Automatic Control in Lund University (Sweden), he joined INRAE in 2006

(previously named Irstea). He supervised several projects and thesis on topic of mobile robot control in harsh environments. He obtained the capability to conduct research in 2011, and currently lead the team Romea (Robotic and Mobility for Environment and Agriculture). He is also in charge of the scientific committee of RobAgri association. His research activities, focused on adaptive and predictive control of mobile robots in the context of natural environment, are deeply applied in the field of agricultural robots.

4) **Title**: *Remote Sensing and Data Analytics for Digital Agriculture – Challenges and Opportunities*
Abstract: Widespread adoption of precision agriculture requires timely acquisition of low-cost, high quality data that support timely assessment of soil and crop health. With recent advancements in sensing and computing technologies, such as unmanned aerial systems (UAS), satellites, and cloud computing, the agricultural community has access to a large volume of data that are richer than ever before. While these data offer great prospects for timely and cost-effective monitoring of crop and soil health for digital agriculture, there are some challenges to their use, including the selection of appropriate sensor for data collection, and data analytics. This talk will focus on some of these challenges and opportunities associated with using UAS and satellite data for monitoring crop yield, pest pressure, and soil health. Lessons learned from some of the past and current projects will be discussed.
Speaker: Sami Khanal, Ohio State University, USA
Bio: Dr. Sami Khanal received the M.Sc. degree in geosciences from the Mississippi State University, USA, in 2009 and the PhD degree in Environment and Resources from the University of Wisconsin-Madison, USA, in 2012. She is currently assistant professor at the Ohio State University. Her research is focused on developing decision support systems to encourage stakeholders including farmers, environmentalists and policymakers to promote and adopt sustainable agricultural production practices. In addition to using freely available data on weather and landscape, her lab uses advanced and emerging technologies such as GIS, global position system and remote sensing (e.g., sensors on broad drones, aircraft, satellite, and ground) to collect data.

5) **Title**: *Large-Scale Monitoring, Expert Input, and the Ecological Impact of Autonomy*
Abstract: This talk will provide an overview of current research efforts in precision grazing systems aimed at deploying multi-robot teams for improved grassland management. Specifically, it will address theoretical efforts in combinatorial optimization for large-scale monitoring, a new forage perception pipeline for aerial robots, and the coupling of robotic measurements with expert models of grassland growth processes. Finally, the talk will conclude with a discussion of the potential ecological impacts of large-scale autonomy.
Speaker: Ryan K. Williams, Virginia Polytechnic Institute and State University, USA
Bio: Ryan K. Williams received the B.Sc. degree in computer engineering from Virginia Polytechnic Institute and State University and the PhD degree in electrical engineering from the University of Southern California, in 2005 and 2014, respectively. He is currently Assistant Professor at the Virginia Polytechnic Institute and State University. His research interests include control, cooperation, and intelligence in distributed multi-node systems, topological methods in cooperative phenomena, and distributed algorithms for optimization, estimation, inference, and learning.