EMERGING sUAS TECHNOLOGY FOR PRECISION AGRICULTURE APPLICATIONS (AGDRONETECH14)

Organizers

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Tutorial Summary

Recently, there has been a rapidly increasing interest in small unmanned aerial vehicles (sUAVs). With the emergence of high power density batteries, long range and low-power micro radio devices, cheap airframes, and powerful micro-processors and motors, small/micro UAVs have become applicable in civilian circumstances such as remote sensing, mapping, traffic monitoring, search and rescue. Many applications and research projects could greatly benefit from having remote sensing (RS) data with high temporal and spatial resolution. However, most of the available RS data is expensive, has low spatial resolution and single feature, is sampled at a low frequency, and/or has a long turnover time.

This tutorial will focus on emerging sUAS technology for precision agriculture applications. According to http://www.precisionag.com/article/35499/precision-ag-2013-top-5-technologies-to-watch drones are, for the first time, listed in the top five technologies to watch in precision agriculture. According to http://www.auvsi.org/econreport, 90% of the potential market for UAVs will be accounted for by public safety and precision agriculture. UAVs will inject $82 billion in economic activity and generate up to 100,000 new jobs between 2015 and 2025. Therefore, it is timely to review emerging sUAS techniques in precision agriculture applications. The fundamental task is how to use sUAS for early detection of crop stresses due to various factors such as water / drought, salinity, nitrogen, pest(s), heat, frost, and mineral(s) in soil. We will also discuss using UAVs in precision application of agro-chemical such as pesticides, growth regulators and etc. We will cover benefits and future potentials of using UAVs in real citrus production by the University of Florida Citrus Research and Education Center (CREC).

This tutorial is the natural outgrowth of the organizers work, which will also be reviewed, in: i.) Multi-UAV based remote sensing platform that was developed to achieve multi-spectrum images with high temporal and spatial resolution including the concept of personal remote sensing; ii.) Development of Thermal Infrared (TIR) personal remote sensing (PRS) technologies with low cost sUAVs used to demonstrate how one can perform UAV-based scientific thermal measurements; iii.) Developing the

complete AggieAir sUAS system, including architecture designs, airworthiness, ground segments (Ground Control Stations as well as safety pilot interfaces), and human factors (crew training and field operations).

Tutorial outline (4 hours, half-day)
1. Introduction to UAV-based Personal Remote Sensing (PRS, or Data Drones): concepts, history, motivation, goals, mitigation of privacy concerns and FAA CoA process (Dr. YangQuan Chen)
2. UAV applications in precision agricultural: benefits and the future potentials (Dr. Reza Ehsani)
3. Vegetation indices and crop stress detection using low-cost drone fleet (Brandon Stark)
4. Optimal UAV crop dusting as a cyber-physical system (Dr. YangQuan Chen and Brandon Stark)
5. Application challenges and solutions (examples and participant mind storming session) (moderated by Dr. YangQuan Chen)

Intended audience
- Graduate students in electrical engineering, mechanical and aerospace engineering, agriculture engineering, and intelligent mechatronics;
- Small unmanned aerial vehicle system engineers;
- Natural resource managers, water engineering professionals;
- Farmers, growers and precision agriculturists;
- UAV practitioners, researchers and developers.

Tutorial Material: *To be delivered to participants via Dropbox invitation and USB jump drive swap.*

<u>Tutorial References</u>

o **White paper (free access): "***AggieAir: Towards Low-cost Cooperative Multispectral Remote Sensing Using Small Unmanned Aircraft Systems,*" Haiyang Chao, Austin Jensen, Yiding Han, YangQuan Chen, and Mac McKee, <u>Advances in Geoscience and Remote Sensing</u>, Gary Jedlovec (Ed.), Vukovar, Croatia: ISBN: 978-953-307-005-6, IN-TECH, pp. 463-490, 2009. Pdf link: http://www.intechopen.com/articles/show/title/aggieair-towards-low-cost-cooperative-multispectral-remote-sensing-using-small-unmanned-aircraft-sys

o Mishra, A. R., D. Karimi, R. Ehsani, and W.S. Lee. 2012. *Identification of citrus greening (HLB) using a VIS-NIR spectroscopy technique*. Transactions of the ASABE, 55 (2): 711-720. http://swfrec.ifas.ufl.edu/hlb/database/pdf/6_IdentificationCitrusGreening_12.pdf

o Garcia-Ruiz, F., S. Sankaran, J.M. Maja, W.S. Lee, W.S., J. Rasmussen, and R. Ehsani. 2013. *Comparison of two aerial imaging platforms for identification of Huanglongbing infected citrus trees*. Computers and Electronics in Agriculture, DOI: http://dx.doi.org/10.1016/j.compag.2012.12.002

o Coopmans, C., Stark, B., Jensen, A., Chen, Y., & Mckee, M. (2013). *Cyber-Physical Systems Enabled by Small Unmanned Aerial Vehicles* (Submitted Chapter). In K. P. Valavanis and G. J. Vachtsevanos (Eds.), <u>Handbook of Unmanned Aerial Vehicles</u>, Springer.

o Stark, B., Coopmans, C., & Chen, Y. (2013). *Concept of Operations of Small Unmanned Aerial Systems: Basis for Airworthiness towards Personal Remote Sensing* (Submitted Chapter). In K. P. Valavanis & G. J. Vachtsevanos (Eds.), <u>Handbook of Unmanned Aerial Vehicles</u>. Springer.

o Invited Tutorial at 2011 ICUAS (Int. Conf. on Unmanned Aerial Systems) (full day) on May 24th, 2011, Denver, CO., on "*Multi-UAV Based Multi-Spectrum Collaborative Personal Remote Sensing: Concepts, Platform & Applications*"

o Invited Tutorial at 2012 ICUAS (Int. Conf. on Unmanned Aerial Systems) (full day) on June 12th, 2012, Philadelphia, PA., on "*Low-cost UAV-based precision thermal infrared (TIR) mapping - A new Personal Remote Sensing capability: UAV platform, TIR payload, in-flight*

calibration and applications."

- o May 28, 2013. Y.Q. Chen, Brandon Stark, A. Jenson, and C. Coopmans. *SUAS Airworthiness, Architecture, and Human Factors*. Invited Half-Day Tutorial at 2013 ICUAS, Atlanta, GA, USA.

Instructor Biographies

YangQuan Chen received his B.S. degree in industrial automation from the University of Science and Technology of Beijing, Beijing, China in 1985, his M.S. degree in automatic control from the Beijing Institute of Technology, Beijing, in 1989, and his PhD degree in advanced control and instrumentation from the Nanyang Technological University, Singapore, Singapore, in 1998. He was the control systems/mechatronics faculty of the Electrical and Computer Engineering Department at Utah State University, Logan, and the Director of the Center for Self-Organizing and Intelligent Systems before joining the University of California, Merced in fall 2012. He is the founder and director of the Mechatronics, Embedded Systems and Automation Lab (MESA Lab) at UC Merced. His lab at UC Merced has obtained FAA CoA in 2013.

Reza Ehsani, PhD is an associate professor of Agricultural and Biological Engineering at the University of Florida/IFAS Citrus Research and Education Center (CREC). His current areas of research include developing tools and techniques for precision agriculture, applications of unmanned aerial vehicle in agriculture, disease and stress detection sensors, automation and mechanization. Dr. Ehsani has a Ph.D. in Biological and Agricultural Engineering from the University of California, Davis, where he worked on precision agriculture applications for high value crops. He was an assistant professor and a precision agriculture specialist at the Department of Food, Agricultural and Biological Engineering at the Ohio State University before joining the University of Florida.

Brandon Stark is a PhD Student and Lab Manager for the Mechatronics, Embedded Systems and Automation Lab (MESA Lab) at the University of California, Merced. He earned his bachelor's degree in computer engineering from the University of California, Irvine in 2007 with a minor in Art History. He continued his graduate education at the University of Bridgeport and earned a Master of Science degree in Computer Engineering and a Master of Science degree in Electrical Engineering in 2010. He started his Ph.D. studies in Utah State University with the Center for Self-Organizing and Intelligent Systems before transferring to University of California, Merced to assist in the founding of the Mechatronics, Embedded Systems and Automation Lab (MESA Lab) and continue his research on the topics of Unmanned Aerial Systems: Airworthiness, Regulations and Human Factors.