A Tutorial Proposal Submitted to ICUAS 2015

(http://www.uasconferences.com) (4 hours)

Full Title:
"Emerging sUAS Technology for Precision Agriculture Applications (AgDroneTech15)"

Short Title:
AgDroneTech15

Web: http://mechatronics.ucmerced.edu/research/unmanned-aerial-systems

Instructors and Organizers

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Brief biographies of Co Organizers:

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 Ph.D. degree in advanced control andinstrumentation 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 scientific data-drone lab at UC Merced has obtained 8 FAA CoAs since 2013.

Reza Ehsani, Ph.D. 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.

Ph.D. students: Brandon Stark, Tiebiao Zhao and Ying She.

Brief statement of the tutorial goals:

Recently, there has been a rapidly increasing interest in small unmanned aerial vehicles (UAVs). 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.

In our ICUAS2011 full day tutorial, we showed our participants how we developed our multi-UAV based remote sensing platform to achieve multi-spectrum images with high temporal and spatial resolution. It includes the concept of personal remote sensing, CSOIS UAV research focus, low-cost UAV platform development for fixed-wing and VTOL aircrafts, the whole system architecture and practical applications.

In our ICUAS2012 tutorial, we focused on TIR (thermal infrared) personal remote sensing (PRS) using small low cost UAVs. In brief, we showed how one can perform UAV-based scientific thermal measurements instead of simple thermal signature surveillance. There were enough details in the proposed tutorial that the participants were able to understand the concepts, the broad applications, and even develop their *own* low-cost UAV platform having TIR capabilities based on the information we presented.

In the ICUAS2013 tutorial, we introduced the AggieAir SUAS system in depth, emphasizing how architecture designs drive airworthiness for SUAS airborne systems (aircraft and payloads), SUAS ground segments (Ground Control Stations as well as safety pilot interfaces), and human factors (crew training and field operations). Participants in this tutorial benefited from our team's more than 5 years' experience designing, implementing, and flying SUASs in real-world mission-oriented scenarios. Participants were given an overall picture of sufficient depth and breadth to grasp the past challenges in implementation of civil scientific measurement SUASs, and a firm grasp of the complexity of future development of SUASs in the civilian airspace.

In the ICUAS2014 tutorial, we focused on some 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 percent 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 also discussed using UAVs in precision application of agro-chemical such as pesticides, growth regulators and etc. We covered benefits and future potentials of using UAVs in real citrus production by the University of Florida Citrus Research and Education Center (CREC).

Now in 2015, we know that in 2014, interestingly, the top 5 technologies to watch in precision ag in 2013 are still the same 5 technologies but in 2014's top 5, drones were ranked #1 (was #5 in 2013)! As more and more exemptions are being awarded by FAA to various commercial entities, AgDroneTech should continue. This year, we plan to present some new results obtained in the past year with an emphasis on real field tests and ground truthing efforts.

Description of the intended audience

- Graduate students in electrical engineering, mechanical & 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 outline (4 hours, half-day)

1. Small UAS (sUAS) as "Scientific Data Drone" for Precision Ag: Certification, Operation, Ground Truthing and Risk Assessment (Dr. YangQuan Chen)
2. UAV applications in precision agricultural: benefits and the future potentials (Dr. Reza Ehsani)
3. Image analysis and algorithms for tree inventory estimation based on aerial imaging (Ying She)
4. The need of new generation of vegetation indices for crop stress early detection (YangQuan Chen/Tiebiao Zhao)
5. TIR and SWIR payloads for sUAS and applications (Brandon Stark)
6. Crop dusting drones (Dr. YangQuan Chen and Tiebiao Zhao)
7. Application challenges and solutions (examples and participant mind storming session) (All: moderated by Dr. YangQuan Chen)

Tutorial Materials:

To be delivered to participants via Dropbox invitation and USB jump drive swap.

Tutorial References:

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, Advances in Geoscience and Remote Sensing, 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

- 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
- 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, V 91: 106â€“115. DOI: http://dx.doi.org/10.1016/j.compag.2012.12.002
- 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 & G. J. Vachtsevanos (Eds.), *Handbook of Unmanned Aerial Vehicles* (1st ed.). Springer.
- 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.), *Handbook of Unmanned Aerial Vehicles*. Springer.
- 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*"
- 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*."
- 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.