

## **Towards Smarter, Safer, More Reliable and More Resilient Intelligent Unmanned Systems**

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**Abstract** – Although the concepts and developments on Fault Detection and Diagnosis (FDD) and Fault-Tolerant Control (FTC) have been progressively and extensively investigated worldwide since the 1970s and 1980s, respectively, the recent catastrophic crashes of two Boeing 737 MAX8 airplanes in 2019 have again highlighted the necessity and urgency for FDD and FTC research & development and their industrial applications. On the other hand, unmanned systems (USs, including Unmanned Aerial Vehicles (UAVs), Unmanned Ground Vehicles (UGVs), Autonomous/Driverless Vehicles (AVs), and other transportation vehicles on the land, on/under the water) are gaining more and more attention and rapid development during the last few years due to their relatively easy and cost-effective uses in various application tasks directly linking to our daily life for better mobility and sustainable development. These new advancements are benefited significantly from technical advances in communication, computation, control, actuators, sensors, networks and new/intelligent designs linked to the rapid development under the framework of Cyber-Physical Systems (CPSs) and widely spread Artificial Intelligence (AI) and Deep Neural Network (DNN) learning technologies. Due to a higher level of size and complexity in systems, in particular the added technical challenges due to the involvement of more electronic devices with both hardware and software and with large-scale and distributed networked systems, artificial cyber-attacks through communication networks, along with physical faults, could occur during systems operation, which will all lead to physical damages of the system and thus critical issues on stability, performance, safety, and security of the normal operations of the above-mentioned USs. In this talk, brief overall view on the challenges and latest developments towards smarter, safer, more reliable and more resilient intelligent unmanned systems in terms of safe and secure controls of these systems by integrating also with Remote Sensing (RS) techniques for applications to forest and environment monitoring and fires/risks/damages detection will be presented first, then some of new developments and current research works being carried out at our group will be introduced as the second part of the presentation. In particular, new developments on autonomous control, FDD, FTC, and Fault/Attack-Tolerant

Cooperative Control (FTCC) techniques towards autonomous, safe and secure operation and applications of USs to the forest fire monitoring tasks in the presence of physical faults and cyber-attacks will be presented.



**Prof. Youmin Zhang** is currently a Professor at the Department of Mechanical, Industrial and Aerospace Engineering and the Concordia Institute of Aerospace Design and Innovation (CIADI) at Concordia University, Canada. Dr. Zhang received his B.Sc., M.Sc., and Ph.D. degrees in Automatic Control Department of Northwestern Polytechnical University, Xi'an, China, in 1983, 1986, and 1995, respectively.

His main research interests and experience are in the areas of condition monitoring, health management, Fault Detection and Diagnosis (FDD) and Fault-Tolerant Control (FTC); cooperative Guidance, Navigation and Control (GNC) of unmanned aerial/space/ground/marine vehicles with applications to forest fires, power lines, wind farms, solar panels arrays, environment, natural resources and natural disasters monitoring, detection, and protection by combining with remote sensing techniques; dynamic systems modeling, estimation, identification and advanced control techniques; and advanced signal processing techniques for diagnosis, prognosis, fault-tolerant and attack-resilient of safety-critical systems with application to unmanned systems, smart grids, and smart cities under the framework of cyber-physical systems. He has published 8 books, over 550 journal and conference papers with high citations. He was awarded as a Concordia University Research Fellow in the Strategic Research Cluster 'Technology, Industry and the Environment' in 2018 in recognition of his outstanding research works and contributions. His research works on developments of unmanned systems with applications to forest fires detection and autonomous transportation have been reported by public media in national (CTV News, Radio-Canada International, Canadian Science Publishing), citywide (La Presse, Ville.Montreal), and organizational (Concordia News, Quanser Inc., Amtek Company) levels several times. Dr. Zhang is a Fellow of IEEE (Institute of Electrical and Electronics Engineers) and CSME (Canadian Society for Mechanical Engineer), President of International Society of Intelligent Unmanned Systems (ISIUS, 2019-2022), Executive Committee Member of International Conference on Unmanned Aircraft Systems (ICUAS), Steering Committee Member of International Symposium on Autonomous Systems (ISAS), and a member of the Technical Committee for several international and national scientific societies. He has been an Editor-in-Chief, an Editor-at-Large, an Editorial Board Member, and Associate Editor of several international journals, including as a Board Member of Governors for "Journal of Intelligent & Robotic Systems", an Editorial Advisory Board Member for "International Journal of Intelligent Unmanned Systems", Associate Editor for "IEEE Transactions on Industrial Electronics", "IEEE Transactions on Neural Networks & Learning Systems", "IEEE Transactions on Circuits and Systems -

II: Express Briefs", "IET Cyber-systems and Robotics", "Unmanned Systems", "Industrial Artificial Intelligence", "Journal of Systems Science and Complexity", "Chinese Journal of Aeronautics", "Security and Safety", Deputy Editor-in-Chief for "Guidance, Navigation and Control" etc. He has served as (Honorary) General Chair, Program Chair of several unmanned systems and renewable energy relevant international conferences, including as the General Chair of 2014 Int. Conf. on Intelligent Unmanned Systems (ICIUS'14) held at Montreal, Canada during Sept. 29-Oct. 1, 2014, a General Co-Chair of ICIUS'16 held at Xi'an, China during Aug. 23-25, 2016, and Program Chair of ICIUS'19 held at Beijing, China during Aug. 27-29, 2019; a General Chair of 2022 Int. Conf. on Unmanned Aircraft Systems (ICUAS'22) held at Dubrovnik, Croatia during June 21-24, 2022, and an Honorary General Chair of the ICUAS'23 to be held at Warsaw, Poland, June 6-9, 2023 (<http://www.uasconferences.com/>); a General Chair of the 5th and 6th Int. Symp. on Autonomous Systems (ISAS'22, ISAS'23) held at Hangzhou, China, April 8-10, 2022 and to be held at Nanjing, China, June 23-25, 2023 (<http://www.isas-conference.com/>); and Program Chair of the IEEE 5th Int. Conf. on Renewable Energy and Power Engineering (REPE'22), Beijing, Sept. 28-30, 2022 (<http://www.repe.net/>). More detailed information can be found at <http://users.encs.concordia.ca/~ymzhang/>.