Dr. Youmin Zhang's Biography

Dr. Youmin Zhang is currently a Professor in the Department of Mechanical, Industrial & Aerospace Engineering and the Concordia Institute of Aerospace Design and Innovation (CIADI), Concordia University, Montreal, Canada.

Dr. Zhang and his team's main research interests and experience are in the areas of condition monitoring, fault diagnosis and fault-tolerant (flight) control systems; cooperative guidance, navigation and control of unmanned aerial/ground/ marine vehicles with various engineering and practical applications; dynamic systems modeling, estimation, identification and control; and advanced signal processing techniques for diagnosis, prognosis and health management of safety-critical and health-critical systems, renewable energy systems and smart grids, and manufacturing processes.

He has published **8 books**, over **550 journal and conference papers** (including **167 journal papers** since 2015), with h-index of 52 and 70 at WoS and Google Scholar. His comprehensive review paper published at *Annual Reviews in Control* on "Bibliographical Review on Reconfigurable Fault-tolerant Control Systems" has gained significant impact in the field worldwide. The paper has been ranked No. 1 in the "Most Cited Articles" published since 1996, and as WoS "Highly Cited Paper", with also other 8 papers.

Prof. Zhang has been invited to give international conference plenary or keynote talks worldwide for more than 40 times since 2005. He serves as a member of the IFAC Technical Committee (TC) on Fault Detection, Supervision and Safety for Technical Processes (SAFEPROCESS), the AIAA on Unmanned Systems Integration, the IEEE Robotics and Automation Society TC on Aerial Robotics and Unmanned Aerial Vehicles (ARUAV), and the ASME/IEEE TC on Mechatronics and Embedded Systems and Applications (MESA) etc.

He is a Board Member of Governors and Regional Representative (North America) of *Journal of Intelligent & Robotic Systems*, Deputy Editor-in-Chief of *Guidance, Navigation and Control* and an Editorial Board Member, (Associate) Editor of 10 other international journals (including 3 journals on *Unmanned Systems*; *IEEE TNNLS*, *TIE*, *TCS-II*). He has served as General Chair, Program Chair, and IPC member of many international conferences. He served as the General Chair of the 10th Int. Conf. on Intelligent Unmanned Systems (ICIUS'14), Montreal, Canada, a Co-General Chair of ICIUS'16, and Program Chair of ICIUS'19; Program Chair of 2014 and 2017 of Int. Conf. on Unmanned Aircraft Systems (ICUAS); A (Honorary) General Chair of the ICUAS'15, '18, '20, '21, '22, 23, and ICUAS'24. A General Co-Chair of ISAS'18, '19, '20, General Chair in ISAS'22, ISAS'23. Dr. Zhang is a fellow of CSME, a senior member of AIAA and IEEE, a member of ASME, AUVSI/USC, CASI, and President of ISIUS (2019-2022).

Diagnosis, Flight Control and Simulation (DFCS) Lab & Networked Autonomous Vehicles (NAV) Lab

Dr. Youmin Zhang, Director
Phone: (514) 848-2424 ext. 5225
Fax: (514) 848-3175
E-mail: youmin.zhang@concordia.ca
Websites: https://users.encs.concordia.ca/~ymzhang/index.html
Videos: https://www.youtube.com/user/NAVConcordia
LinkedIn.com/in/youmim-zhang-a5309439
ORCID: https://orcid.org/0000-0002-9731-5943
Google Scholar: https://scholar.google.ca/citations?hl=en&user=t2L3NAIAAAAJ

Address

Concordia University
Department of Mechanical, Industrial & Aerospace Engineering
Concordia Institute of Aerospace Design and Innovation (CIADI)
1455 de Maisonneuve Blvd, W.

Funding Agency and Industrial Collaborators

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NUMÉRICA TECHNOLOGIES INC.
OPAL-RT TECHNOLOGIES

Concordia University
Engineering and Computer Science

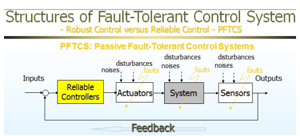
Research Areas

- Sense & Avoid (S&A), Guidance, Navigation, Control (GNC) of manned and unmanned vehicles (aerial, space, ground, marine)
- Systems modelling, estimation, identification, and simulation techniques
- Monitoring, physical fault and cyber-attack detection and diagnosis, prognosis and health management, fault-tolerant and cyber-resilient guidance, navigation and control techniques
- Cooperative control of multiple vehicles under normal and fault conditions
- Unmanned vehicles and remote sensing techniques applied to forest fires, pipelines, power lines, heritage structure inspection, environment, natural resources and disasters monitoring, detection, and protection
- Health monitoring, fault/attack diagnosis, self-healing control of gas engines, wind turbines, photovoltaic array, renewable energy systems, smart grids, smart cities, and human health
- Human/Animal health, machining tools and machining processes condition monitoring, diagnosis, and prognosis

Fault Diagnosis and Fault-tolerant Control

Passive Fault-tolerant Control Design

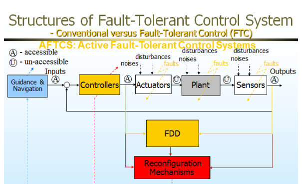
The philosophy of passive FTC (also named as reliable controller earlier) is that a set of faulty cases as well as the normal condition are taken into account at the design stage. In the passive FTC design procedure, the less conservative algorithms are proposed with consideration of safety requirements in flight control systems.



In accordance with the natural safety requirements, the design algorithms with consideration of practical issues, including actuator saturation and safety bounds are developed.

Active Fault-tolerant Control Design

An active FTC system reacts to system component malfunctions (including actuators, system itself, and sensors) by reconfiguring the controller based on the real-time information from a Fault Detection and Diagnosis (FDD) unit. An active FTC typically consists of an FDD scheme, a reconfigurable controller, and a controller reconfiguration mechanism. These three units have to work in harmony to complete successful control tasks. Based on this architecture, the design objectives of an active FTCS are (1) to develop an effective FDD scheme to provide information about the fault with minimal uncertainties in a timely manner; (2) to reconfigure the existing control scheme effectively to achieve stability and acceptable closed-loop system performance; and (3) to commission the reconfigured controller smoothly into the system by minimizing potential switching transients.



The active FTC design approaches developed by the research group, including FDD methods based on Kalman filter, two-stage Kalman filter, reconfiguration based on multi-model control, reconfigurable control with explicit consideration of system performance degradation, have drawn significant interests and citations in worldwide.

The proposed FTC design methods have not only been validated by the nonlinear benchmark aircraft models (i.e. Boeing 747, ADMIRE), but also implemented in the Quadrotor UAVs in DFCS & NAV

Cooperative Control for Multiple Unmanned Systems

Sense and Avoid Technology Development

In the research and development process of multiple UAV systems, how to integrate Sense & Avoid (S&A) function into the autopilot to protect against collisions with other UAVs is of paramount importance. It is a common understanding that the widespread applications of UAVs will not be possible unless this capability is available. Establishing an effective solution to the S&A technique in multiple UAVs plays a profoundly important role in the application of multiple UAVs. Once the algorithm in response to the sensors equipped on UAVs is developed, the relevant characteristics can be implemented by software in the autopilot . Such a research has been carried out with collaboration of local aerospace industry Marinvent Inc.

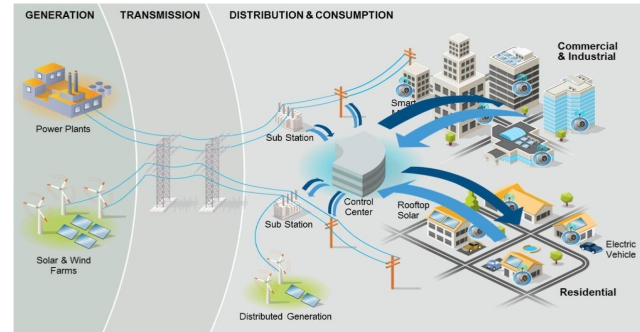
Forest Fires/Power Lines Monitoring & Protection Using UAVs

This project is to develop a fleet of UAVs system with remote sensing sensors (color, infrared, thermal etc.) to detect, track, and predict the time and range evolution of forest fires (or breakages of power lines). Fire detection must be done as fast as possible since small fires are easier to be controlled and terminated whereas fire tracking and prediction aims to track and predict the evolution of the fire in time in function of the information provided by the UAVs.

Cooperative Control for Multiple Unmanned Systems

The overall objective is to develop a fleet of UAVs system with remote sensing sensors (color, infrared, thermal etc.) to complete specific tasks. To reach this goal, the specific objectives are the development of 1) UAV frames to carry the payload (including the remote sensing sensors for day-time, night-time, bad weather conditions etc.) for surveillance; 2) Remote sensing sensors for monitoring; 3) Sensor fusion techniques and image processing techniques for decision-making and localization; 4) Guidance, Navigation, Control (GNC) strategies and algorithms for single UAV and a fleet of UAVs; 5) Cooperative localization, deployment, and control strategies of a fleet of UAVs with remote sensing sensors for optimal coverage; 6) Autonomous path planning and re-planning strategies; 7) Ground station development for safe and efficient operation of the UAVs system.

Renewable Energy & Smart Grids



Dr. Zhang was living in Ontario during the famous blackout that shut down Toronto and much of the American northeast in 2003. Days without electricity convinced Dr. Zhang that there was a need to improve the systems that we all rely on to heat, cool and power our buildings. He now also works in the area of fault diagnosis and fault-tolerant control for "smart grids" — fully modernized grids capable of providing power that is reliable, efficient, cost-effective, and environmentally responsible. Fundamentally, the smart grid must be capable of providing power from multiple and widely distributed sources such as wind turbines, concentrating solar power systems, photovoltaic panels and perhaps even plug-in hybrid electric vehicles. Such a smart grid adds two-way communication and control capabilities to the existing grid. It allows power to be distributed more efficiently and reliably. It also allows homeowners and businesses to use electricity more economically.

To achieve a practical smart grid, a wide range of knowledge and technologies must be developed and implemented. However, one of key technologies is to make use of advanced health monitoring and FTC technologies including the devices and algorithms that will analyze, diagnose, and predict grid conditions and autonomously take appropriate corrective actions against grid faults/emergency conditions in order to mitigate, eliminate, and prevent outages and power quality disturbances. In this regard, the main objective of this research work is to develop monitoring, FDD and FTC technologies for realization of self-healing smart grids concept including distributed and renewable generation units to improve the reliability, availability, and efficiency of the whole grid system.

To maintain reliable delivery of electrical power, monitoring and inspection of power-lines with UAVs become more and more important and popular, this is also one of our current research focuses.

For more and latest information on the new research activities, research outcomes, and new publications of the DFCS Lab and NAV Lab under the direction of Prof. Youmin Zhang, please check:
Website: http://users.encs.concordia.ca/~ymzhang/

Web: https://users.encs.concordia.ca/~ymzhang/index.html

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