

## Workshop/Tutorial T1 (Full Day)

### NEW DEVELOPMENTS ON SENSE-AND-AVOID (S&A), FAULT-TOLERANT CONTROL (FTC) AND FAULT-TOLERANT COOPERATIVE CONTROL (FTCC) TECHNIQUES FOR UNMANNED SYSTEMS AND THEIR APPLICATIONS

#### Organizers and Presenters

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#### **Tutorial Summary**

Unmanned systems including Unmanned Aerial Vehicles (UAVs) or Unmanned Aircraft Systems (UAS), Unmanned Ground Vehicles (UGVs), and Unmanned Surface/Underwater Vehicles (USVs/UUVs) have gained increased attention during the last years due to their utilization in diverse applications such as surveillance, search and rescue missions, geographic studies, military, security, etc. Sense and Avoid (S&A) is required to enable UAS integration into airspace, while Fault-Tolerant Control (FTC) and Fault-Tolerant Cooperative Control (FTCC) techniques contribute to guaranteeing safety of unmanned systems. Based on prior and ongoing research and development and experience gained at the Diagnosis, Flight Control and Simulation Lab (DFCSL) and Networked Autonomous Vehicles Lab (NAVL) at Concordia University, this tutorial will present state-of-the-art techniques in S&A, Fault Detection and Diagnosis (FDD), FTC, as well as FTCC of multiple vehicles with applications to forest fire monitoring and detection and power line inspection, using different types of unmanned systems including UAVs, UGVs, and USVs by combining with remote sensing techniques. Additional applications to wind turbines/farms and smart grids are also discussed.

An overview of past, current and future research activities and research outcomes on S&A, FDD, FTC, and FTCC and their implementation to quadrotor rotary and fixed-wing UAVs will be presented. Linear and nonlinear techniques for modeling, fault diagnosis, fault-tolerant control, path and trajectory planning/re-planning, cooperative and formation flight guidance, navigation and control, based on a quadrotor helicopter UAV and fixed-wing UAV test beds at NAVL, as well as USVs worldwide, will be discussed. A review of developed vision-based automated forest fire detection and power line inspection systems using UAVs combining imaging processing techniques with deep learning methodologies etc., and key issues towards practical and reliable applications of UAVs will also be presented.

#### **Tutorial Outline**

- **09:00 – 9:45:** Introduction to Sense and Avoid (S&A), Fault Detection and Diagnosis (FDD), Fault-tolerant Control (FTC), and Fault-tolerant Cooperative Control (FTCC): Motivation, Concept, History, Existing and Future Developments
- **9:45 – 10:30:** Developments on FDD, FTC and FTCC with Applications to Fixed-wing and Quadrotor UAVs Testbeds
- **10:30 – 10:45:** Coffee Break
- **10:45 – 11:00:** Design of FTC Methods Based on Reliability
- **11:00 – 11:45:** New Development on UAV Sense and Avoid (S&A) Techniques
- **11:45 – 14:00:** Lunch Time
- **14:00 – 14:45:** New Development on Forest Fire Detection for Real-time Monitoring Using UAVs and Remote Sensing with Deep Learning Techniques
- **14:45 – 15:00:** Coffee Break
- **15:00 – 15:45:** An Overview and New Development on Remote Sensing and Computer Vision Technologies Used for Automatic Power Line Inspection with UAVs
- **15:45 – 16:30:** FTCC of Multiple UAVs-UGVs in the Presence of Actuator Faults During Forest Fire Monitoring Mission
- **16:30 – 17:15:** Guidance, Navigation and Control (GNC) of Unmanned Surface Vehicles: From Design to Implementation
- **17:15 – 17:30:** Summary, Discussion, and Feedback

### Intended Audience

This Tutorial is suitable for graduate students and researchers, managers, practitioners, end-users and developers interested in unmanned systems (UAVs, UGVs, USVs), sense and avoid, remote sensing, fault-tolerant and cooperative control, fault diagnosis, health management, fault-tolerant guidance, navigation and control, and applications to forest fire, power line, pipeline monitoring and fault/damage detection etc. The collective outcome of the Tutorial is an understanding of the state-of-the art in the topical areas of the Tutorial.

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