AER1216: FUNDAMENTALS OF UAS

Centre for Aerial Robotics Research and Education

Fall 2021

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Curriculum

This graduate course is offered as part of CARRE program in UAVs. This course is the first part of CARRE core courses. [1] The objective of the course is to teach the fundamentals of fixed wing (FW) and multi-rotor (MR) UAVs.

- The course will cover introductory materials for fixed wing and multi-rotor UAVs. As multi-rotors are rather new compared to fixed wing the multi-rotor material will be less refined in general.
- Objective: through this course students are expected to be able to model UAVs based on their configurations, understand flight performance, and conduct UAVs' dynamics and control analysis, demonstrated by simulations.

[1] The second one is AER1217: Autonomy of UAS.

Course Information

ONLINE: ASYNCHRONOUS

- schedule: Thursdays 9:10 – 12:00
- online (**RECORD**ed) lectures
- **SYNC**hronous tutorials
- **SYNC**hronous office hours

Access Tools

- course: Quercus (with your UTORID)
- recorded lecture videos: mymedia.library.utoronto.ca (with your UTORID)
- assignments and project: MATLAB and SIMULINK

Schedule

Date	Topic	Lecturer	Assignments
Sept 9th	**SYNC** Course Outline **RECORD** 1. Introduction to UAVS and operations	Prof. Liu Prof. Grant	
Sept 16th	**RECORD** 2. Aerodynamics Part I and II **SYNC** Tutorial: Introduction to MATLAB/SIMULINK	Prof. Zingg TA	A1
Sept 23rd	**SYNC** Office Hour: Aerodynamics	Prof. Zingg	
Sept 30th	**RECORD** 3. Fixed Wing Configuration/Layout **RECORD** 4. Multi-rotor Configuration/Layout **RECORD** 5. Propulsion/Propellers	Prof. Grant Prof. Waslander Prof. Grant	due A1
Oct 7th	**SYNC** Office Hour: MR Configurations **SYNC** Office Hour: FW Configurations and Propulsion	Prof. Waslander Prof. Grant	A2
Oct 14th	**SYNC** Office Hour: Assignment 1 Review	TA	
Oct 21st	**RECORD** 6. Fixed Wing Performance **RECORD** 7. Multi-rotor Performance	Prof. Liu Prof. Grant	A3, due A2
Oct 28th	**SYNC** Office Hour: Performance **SYNC** Office Hour: Assignment 2 Review	Prof. Grant/Liu TA	
Nov 4th	**RECORD** 8. Fixed Wing Dynamics and Control Part I and II	Prof. Liu	A4, due A3
Nov 11th	**SYNC** Project Description **SYNC** Office Hour: FW Dynamics and Control	Prof. Liu / TA Prof. Liu	
Nov 18th	**RECORD** 9. Multi-rotor Dynamics and Control Part I - III	Prof. Schoellig	A5, due A4
Nov 25th	**SYNC** Office Hour: MR Dynamics and Control **SYNC** Office Hour: Assignment 4 Review **SYNC** Office Hour: Project Consulting	Prof. Schoellig TA Prof. Liu/TA	
Dec 2nd	**SYNC** Office Hour: Project Consulting	Prof. Liu/TA	due A5
Dec 9th	**SYNC** Office Hour: Project Consulting **SYNC** Office Hour: Assignment 5 Review	Prof. Liu/TA TA	
Dec 16th	**SYNC** Project Demonstration	Prof. Liu/TA	due Report

Synchronous vs Asynchronous

- asynchronous (recorded) 9 lectures video: approximately follow 3hr (180min) contents per week
- all released, to give you maximum flexibility to manage your time some new recordings may be updated (with anouncement)
- please complete studying the recordings before scheduled live/synchronous office hours with the instructors.
- synchronous (live) tutorials with TAs and office hours with instructors
- detailed synchronous session time spots will be posted on Quercus
- no recording for synchronous delivery

Grading

- Individual Assignments (50%)
  - Assignment 1: aerodynamics
  - Assignment 2: configurations and propulsion
  - Assignment 3: performance
  - Assignment 4: fixed wing dynamics and control
  - Assignment 5: multi-rotor dynamics and control
- Group Project
  - Simulation Demonstration (15%)
  - Project Report (35%)

Project: FW and MR UAV Modelling and Simulation

One fixed-wing UAV configuration and one multi-rotor UAV configuration will be introduced. Each group will work on both configurations, by performing the following tasks:

1. aerodynamic analysis
2. propulsion analysis
3. performance analysis
4. dynamics modelling
5. basic control development
6. Matlab/Simulink simulation implementation
7. simulation, data collection and analysis
8. documentation: report

References

1. B. Etkin, Dynamics of Atmospheric Flight, John Wiley and Sons, 1972.
2. L. Reid and B. Etkin, Dynamics of Flight: Stability and Control, John Wiley and Sons, 1995.
3. J. D. Anderson, Introduction to Flight 6th edition, McGraw-Hill, 2008.
4. J. D. Anderson, Fundamentals of Aerodynamics, McGraw-Hill, 2001.
5. D. Raymer, Aircraft Design: A Conceptual Approach, AIAA, 2013.
6. B. McCormick, Aerodynamics, Aeronautics, and Flight Mechanics, John Wiley and Sons, 1994.
7. Q. Quian, Introduction to Multi-copter Design and Control, Springer, 2017.
8. Johnston, W., Rotorcraft Aeromechanics, Cambridge University Press, 2013.

Some Advice

- this is a introductory course: many topics to be covered at high-level
- this is a graduate course: fast pace, self study, open-end assignments/project
- this is an online course: take advantage of it flexibility yet be prepared to be effective/efficient with limited interaction with TAs/instructors
- to maximize your educational experience: serious but take it easy