Department of Mechanical and Aerospace Engineering

MAE 275, Unmanned Aerial Systems
Spring Quarter 2017

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Office Hour: 11:00 am – 12:00 pm on Fridays or by appointment
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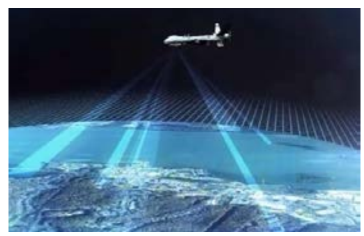
COURSE SUMMARY





Unmanned Aircraft Systems (UAS) have seen unprecedented levels of growth in military and civilian application domains. Fixed-wing aircraft, heavier or lighter than air, rotary-wing (rotorcraft, helicopters), vertical takeoff and landing (VTOL) unmanned vehicles are being increasingly used in military and civilian domains for surveillance, reconnaissance, mapping, cartography, border patrol, inspection, homeland security, search and rescue, fire detection, agricultural imaging, traffic monitoring, to name just a few application domains.

This course offers an introductory study of UAS. Our primary focus is on the challenges that are inherent in guiding and controlling limited-payload small and miniature aircraft systems (with quad-rotor mini-rotorcraft as the main system of interest). The target audiences are aerospace engineering students seeking an introduction to autonomous systems and mechanical engineering, agricultural engineering, electrical engineering, computer engineering, and computer science students who have had a course in introductory feedback control or robotics and interested in unmanned aircraft.

PREREQUISITES

The course will assume basic knowledge of concepts from control (EME 172 or an equivalent course) and dynamics (ENG 102 or equivalent course). A familiarity with simulation tools, such as Matlab/Simulink, will be expected from the students.

STRUCTURE AND EXPECTATIONS

The course will be have three main components: lectures, homeworks, and a project.

Lectures Students will be expected to attend lectures and to have read the assigned reading prior to the lecture. The reading will come from the textbook, and from recent research papers in the field.

Homeworks Homeworks will be assigned bi-weekly throughout the quarter. At the end of every chapter is a project assignment. The idea is to develop a complete flight simulator by the end of the quarter. Of course, all homeworks should contain your own original work.

Project There will be a significant project component to this class involving three steps. First, the students will also be provided with a list of projects solicited from major UAV companies. They can choose one project from the list. The students are also allowed to proposal their own projects. They will need to write a brief proposal for what they intend to do. Second, students will conduct a literature review in the area relevant to the project. Finally, students will carry out the research project and produce a written research report as well as an oral presentation for the class. Choosing a project that dovetails with your graduate research is highly encouraged. Please check "Mid Term Proposal Instruction" and "Final Project Instruction" for details.

GRADING POLICY

The final course grade will be assigned according to the following weighting:

- Homeworks 50%
- Course project 50%
    - Literature review 10%
    - Proposal 10%
    - Final report/presentation 30%

COURSE TOPICS

Week	Topic
1	Introduction: History, Applications, UAV Classification Coordinate Frames: Rotation Matrices, Coordinate Frames, The Wind Triangle
2	Kinematics and Dynamics of Quadcopter
3	Linear Design Models
4	Autopilot Design Using Successive Loop Closure: Successive Loop Closure, Digital Implementation of PID Loops
5	Sensors Models: Accelerometers, Rate Gyros, Pressure Sensors, Digital Compasses, GPS, LIDAR, RADAR

6	State Estimation: Low-Pass Filters, State Estimation by Inverting the Sensor Model, Dynamic-Observer Theory, Kalman Filter, Attitude Estimation, GPS Smoothing
7	Design Models for Guidance: Autopilot Model, Kinematic Model of Controlled Flight, Kinematic Guidance Model, Dynamic Guidance Model
8	Straight-Line and Orbit Following
9	Path Manager and Path Planning: Dubins Paths, Transition Between Waypoints, Point-to-Point Algorithms, Coverage Algorithms
10	Integration and Advanced Topics Project Presentations

COURSE MATERIAL

- There is no required textbook for the course. Handouts and online resources will be distributed for the lectures.
- Recommended References:
  - Randy Beard, Timothy McLain, **Small Unmanned Aircraft: Theory and Practice**, Princeton University Press, 2012.
  - Peter Corke, Robotics, **Vision and Control: Fundamental Algorithms in MATLAB**, Springer, 2013
- Other References:
  - Kimon P. Valavanis, George J. Vachtsevanos, **Handbook of Unmanned Aerial Vehicles**, Springer, 2015. Available online: http://link.springer.com/referencework/10.1007%2F978-90-481-9707-1