

CSE 491/691: Introduction to Aerial Robotics

Kostas Alexis

Spring 2016

Instructor information

- Your instructor is **Kostas Alexis**
- His email address is `kalexis@unr.edu`
- Office hours by appointment, unless we come up with something better.

Course description and prerequisites

Official Course Description: Aerodynamics, Dynamics of Flight, Inertial Sensors, State Estimation Theory, Inertial Navigation Systems, Flight Control Systems, PID Control, Linear Quadratic Regulator, Model Predictive Control, Autopilot Design, Motion Planning Theory, Boundary Value Solvers, Sampling-based methods, Collision-free Navigation, Coverage Path Planning, Aerial Robot Autopilot Holistic Design

Kostas' Description: This course aims to introduce students (from Computer Science, Electrical Engineering and Mechanical Engineering) to the concepts of unmanned aircraft modeling, state estimation, control, as well as into the very basics of motion planning. In particular we will derive the models of unmanned rotorcraft, introduce the concepts of Kalman Filtering for linear and nonlinear systems, methods for closing the loop with stability analysis as well as basic algorithms that robots can employ to efficiently navigate in their environment. The final section of the course is about the collective design - first of all in the classroom - of the algorithms that enable an aerial vehicle to become an autonomous aerial robot. This effort is supported by an open-source simulation and the students will have the opportunity to implement their designs and ideas.

List of course materials

Online Textbook: *CS491/691 Introduction to Aerial Robotics* by Kostas Alexis. The textbook website is <http://www.kostasalexis.com/online-textbook.html>. For the first year of this course, each section will be updated before the corresponding lecture.

Textbook: *Small Unmanned Aircraft: Theory and Practice* by R. Beard, and T. W. McLain. This is a relatively short and good introductory book on aerial robots modeling and control.

Course Website: <http://www.kostasalexis.com/introduction-to-aerial-robotics.html>

Topics outline

The course will cover the main challenges of designing an aerial robot capable of autonomous navigation. Tentatively, here's what we're going to cover:

- **Introduction**
 - What is an Aerial Robot

- **Modeling and Dynamics Formulation**
 - Frame Rotations and Representations
 - Dynamics of a Multirotor Micro Aerial Vehicle
 - Dynamics of a Fixed-Wing Unmanned Aerial Vehicle
- **State Estimation**
 - Inertial Sensors
 - The Kalman Filter
 - Inertial Navigation Systems
- **Flight Controls**
 - PID Control
 - LQR Control
 - Linear Model Predictive Control
 - An Autopilot Solution
- **Motion Planning**
 - Holonomic Vehicle Boundary Value Solver
 - Dubins Airplane model Boundary Value Solver
 - Collision-free Navigation
 - Structural Inspection Path Planning
- **Case Study**
 - Design problem
 - Steps to Design an Autopilot Solution
- **The Future of Aerial Robotics**

Approximate schedule of exams

The final exam will be comprehensive and towards the end of the semester. The mid-term exam will be approximately at the half of the progress of the course. The exact dates will depend on our progress through the material.

There will also be weekly quizzes, on Tuesdays.

Grading

Your grade will be determined by your performance on the quizzes and exams. The percentage (tentative) breakdown is:

- 40% Design Project with intermediate reporting
- 15% Homework
- 20% Mid-term exam
- 25% Final exam

Graduate students are expected to have a much more intensive and research-oriented project.

Statement on Academic Dishonesty

Cheating, plagiarism or otherwise obtaining grades under false pretenses constitute academic dishonesty according to the code of this university. Academic dishonesty will not be tolerated and penalties can include canceling a student's enrollment without a grade, giving an F for the course or for the assignment. For more details, see the University of Nevada, Reno General Catalog.

Statement of Disability Services

Any student with a disability needing academic adjustments or accommodations is requested to speak with the Disability Resource Center (Thompson Building, Suite 101) as soon as possible to arrange for appropriate accommodations.

Statement on Audio and Video Recording

Surreptitious or covert video-taping of class or unauthorized audio recording of class is prohibited by law and by Board of Regents policy. This class may be videotaped or audio recorded only with the written permission of the instructor. In order to accommodate students with disabilities, some students may be given permission to record class lectures and discussions. Therefore, students should understand that their comments during class may be recorded.

Statement for Academic Success Services

Your student fees cover usage of the Math Center (775) 784-4422, Tutoring Center (775) 784-6801, and University Writing Center (775) 784-6030. These centers support your classroom learning; it is your responsibility to take advantage of their services. Keep in mind that seeking help outside of class is the sign of a responsible and successful student.