University Of California, Berkeley
Department of Mechanical Engineering

ME 292B-003 – Control and dynamics of unmanned aerial vehicles (3 units)

Syllabus

DESCRIPTION

This course introduces students to the analysis and control of unmanned aerial vehicles (UAVs). The course will cover modeling and dynamics of aerial vehicles, and common control strategies. Laboratory exercises allow students to apply knowledge on a real system, by programming a microcontroller to control a UAV.

COURSE PREREQUISITES

ME132 (or equivalent, taken simultaneously)

Recommended: Dynamics (e.g. ME104 or similar)

TEXTBOOK(S) AND/OR OTHER REQUIRED MATERIAL

To be made available online.

COURSE OBJECTIVES

Introduce the students to analysis, modeling, and control of unmanned aerial vehicles. Lectures will cover:

- Principle forces acting on a UAV, including aerodynamics of propellers
- The kinematics and dynamics of rotations, and 3D modeling of vehicle dynamics
- Typical sensors, and their modeling
- Typical control strategies, and their pitfalls
- Programming a microcontroller

During the laboratory sessions, students will apply these skills to create a model-based controller for a UAV.

DESIRED COURSE OUTCOMES

At the end of the course, students are able to:

- reason about the dominant effects acting on a UAV
- explain and derive dynamic relationships governing UAV flight

- explain different sensors available on a UAV
- As part of a team:
    - design a nested controller for a quadcopter UAV
    - implement a controller in C++, compile & flash code to a microcontroller

TOPICS COVERED

- Principle forces acting on a UAV, including aerodynamics of propellers
- The kinematics and dynamics of rotations, and 3D modeling of vehicle dynamics
- Typical sensors, and their modeling
- Typical control strategies, and their pitfalls
- Programming a microcontroller

CLASS/LABORATORY SCHEDULE

Three hours of lecture per week, and three hours of laboratory every second week.

CONTRIBUTION OF THE COURSE TO MEETING THE PROFESSIONAL COMPONENT

Students become comfortable working with an advanced robotics system, and related computer tools. Students can reason about practical considerations relating to constrained systems such as UAVs.

RELATIONSHIP OF THE COURSE TO ABET PROGRAM OUTCOMES

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(g) an ability to communicate effectively
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

ASSESSMENT OF STUDENT PROGRESS TOWARD COURSE OBJECTIVES

graded laboratory reports [30%]
midterm exam [30%]
final exam [40%]

SAMPLE OF WEEKLY AGENDA

1. Introduction to UAVs
2. Introduction to programming the system I
3. Aerodynamics of a thin aerofoil, propeller dynamics

4. Modeling of 3D rigid bodies
5. 3D Kinematics
6. 3D Dynamics (Newton-Euler equations), inertial sensors
7. Introduction to estimation
8. Dynamics of UAVs
9. Control and stabilization: computing an equilibrium, linearization
10. Nested control loops, separation principle
11. Trajectory generation and tracking
12. Rotation formalisms: rotation matrix, quaternions
13. Dynamics of unforced rotations
14. Comparison of different vehicle designs: helicopter / fixed-wings

PERSON(S) WHO PREPARED THIS DESCRIPTION
Mark Mueller, 2018-07-25