UUM 532 Spacecraft Control Systems
Spring 2017-2018
Syllabus

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Lecture Times and Office Hours

Time: Tuesdays 14:30-17:30
Place: Faculty of Aeronautics and Astronautics, Classroom D210
Prof. Ure Office Hours: By appointment

Course Objectives

- To provide students a solid understanding of spacecraft and missile attitude dynamics.
- To present applications of classical and modern control theory to design of guidance, navigation and control systems for spacecraft and missiles.
- To provide students with the simulation and analysis tools required to perform graduate level research in spacecraft and missile control systems.

Prerequisites

A good knowledge of basic

- Linear Algebra and Differential Equations
- System Dynamics
- Feedback Control Systems
- Scientific Programming

Lecture Topics

- **Lecture 0: Introduction**
  - Overview of the course

Part I: Spacecraft Attitude Dynamics

- **Lecture 1: Frames and Transformations**

  - Review of Mathematics
  - Reference Frames
  - Euler's Rotation Theorem
  - Attitude Representations
- **Lecture 2: Attitude Kinematics and Dynamics**
  - Attitude Parametrization
  - Attitude Parametrization
  - Attitude Dynamics
- **Lecture 3: Sensors and Actuators**
  - Star Trackers
  - Sun and Earth Sensors
  - Mangetometers
  - GPS
  - Gyroscopes
  - Reaction Wheels
  - Control Moment Gyros
  - Magnetorquers
  - Thrusters

Part II: Attitude Determination and Control

- **Lecture 4: Static Attitude Determination**
  - TRIAD Algorithm
  - Wahba's Problem
  - MLE Estimates
  - TRMM Algorithm
  - GPS Attitude Determination
- **Lecture 5: Dynamic Attitude Determination**
  - Kalman Filtering For Attitude Determination
  - Steady State Calibration
  - Magnetometer Calibration
- **Lecture 6: Attitude Control**
  - Regulation
  - Tracking
  - Detumbling and Momentum Dumping
  - Dealing with Noise

Part III: Missile Guidance

- **Lecture 7: Homing Guidance**
  - Pursuit Guidance
  - Proportional Navigation
  - Velocity-to-be-gained
  - Closed Loop Guidance
  - Combined Navigation and Guidance
- **Lecture 8: Ballistic Guidance**
  - 2D Hit Equation
  - 3D Error Analysis
  - Effect of Earth's Rotation and Geophysical Properties
  - Miss Analysis
- **Lecture 9: Optimal Guidance**
  - Maximum Principle
  - Dynamic Programming
  - Introduction to Differential Games

Textbooks

- *Main Textbook*: Markley, F. Landis, and John L. Crassidis. Fundamentals of Spacecraft Attitude Determination and Control. Vol. 33. New York: Springer, 2014.
- Schaub, Hanspeter, and John L. Junkins. Analytical mechanics of space systems. AIAA, 2003.
- Kabamba, Pierre T., and Anouck R. Girard. Fundamentals of Aerospace Navigation and Guidance. Cambridge University Press, 2014.

Grading

- Problem Sets (20%)
- Take-home Midterm (20%)
- Term Project (30%)
- Take-home Final Exam (30%)

Grading Policies

- Cheating is strictly monitored and the penalty is -100 (minus hundred) points per assignment.
- Late assignments get -30 (minus thirty) points for each day after the deadline.
- No team work is allowed on problem sets and exams.
- Solutions typeset with LaTeXget +10 bonus points.
- Each problem set will also contain a bonus problem, which will earn the student +10 bonus points if solved correctly.

Classroom Policies

- No attendance is required.
- Coming late to the class is tolerated.
- Bringing computers to the class is welcome.
- Unregistered listeners are welcome.
- Interacting with the the instructor is strongly recommended.