CSE 491/691: Autonomous Mobile Robot Design

Kostas Alexis

Fall 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: Actuation, propulsion, system dynamics, sensing, state estimation, control and guidance, motion planning theory, remote control, hollistic robot design, application–oriented robotics.

Description: This course aims to introduce students (from Computer Science, Electrical Engineering, Mechanical Engineering and beyond) into the holistic design of autonomous robots - from the mechatronic design to sensors and intelligence. The course will have five "teaching blocks", namely: a) actuation and robot locomotion, b) sensing and robot perception, c) control and robot guidance, d) motion planning and autonomous navigation, e) remote control and robot GUI and will be project-driven. The students will be organized into teams and each team will design a robot in order to address a specific application and challenge. The final challenges will be derived based on real-requirements of federal agencies or needs of specific industries. Overall the course aims to develop fundamental knowledge in robotics and engage both undergraduate and graduate students in cutting-edge research.

List of course materials

Textbook: *Autonomous Mobile Robots* by Roland Siegwart, Illah Reza Nourbakhsh and Davide Scaramuzza. This is a relatively short and good introductory book on robotics.
Textbook: *Handbook of Robotics, second version* edited by B. Siciliano, O. Khatib. This is a reference book for most robotic fields.
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Lectures: *Course Lectures* by Kostas Alexis
Course Website and further material: `http://www.kostasalexis.com/autonomous-mobile-robot-design.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 a robot

  - What are the major robotic challenges
  - How to do hollistic robotic design
- **Propulsion and Robot Locomotion**
  - Frame Rotations and Representations
  - Propulsion systems and actuation
  - Robot System Dynamics
- **Perception and State Estimation**
  - Inertial Sensors and GPS
  - Camera Sensors
  - LiDAR
  - Furthe Sensing Modalities
  - State Estimation Theory
  - The Kalman Filter
  - Simultaneous Localization And Mapping
- **Flight Controls**
  - PID Control
  - LQR Control
  - Linear Model Predictive Control
  - An Autopilot Solution
- **Guidance and Control**
  - Introduction to Control Theory
  - Feedback Control Fundamentals
  - PID, LQR and MPC laws
  - Guidance laws for nonholonomic systems
- **Path Planning**
  - Holonomic Vehicle Boundary Value Solver
  - Dubins Airplane model Boundary Value Solver
  - Collision-free Navigation
  - Structural Inspection Path Planning
  - Autonomous Exploration
- **Robot Remote Control**
  - Robot Remote Control
  - Graphical User Interface design
  - Augmented Reality–assisted robot control
- **Team Project**
  - Design problem
  - Team Guidance and Work for Project Accomplishment. Available projects for Fall 2016: a) Autonomous Cars Navigation, b) Robots to Study Lake Tahoe, c) Aerial Robotics for Climate Monitoring and Control, d) Aerial Robotics for Nuclear Site Characterization, e) Smartphone-assisted Delivery Drone Landing.

Evaluation and Grading

There are two options for student evaluation:

- Project–based: You will be evalaluted 80% based on your project results and 20% from your final exam. In cases of overachieving performance within the project you will be able to get up to 90% of your grade from the project alone.
- Exams–based: You will be evaluated 40% from the final exam, 40% from your project and 20% from a midterm exam. In case of exam–excellence you will be able to extend its weight from 50% to 60%.

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

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 optional quizzes with a bonus–grade system.

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.