USC Viterbi
School of Engineering

Introduction to Robotics

Units: 4
Schedule: Mon / Wed 3:30 - 4:50pm
Location: LVL 17
Instructor: Stefanos Nikolaidis
Office: RTH 401
Office Hours: 5:30pm – 6:30pm (Mon / Wed)
Contact Info: nikolaid@usc.edu

Instructor: Stefanos Nikolaidis (nikolaid at usc dot edu)

TAs: Aravind Kuramaguru, David Millard, Gautam Salhotra

Course Description: This class will introduce students to the fundamental questions in robotics: what are good models of the world and how to integrate them reliably into the planning of deployed robotic systems physically interacting with the environment. All these problems arise from the uncertainty due to sensor noise, modeling limitations, approximations in algorithmic computations and inherent unpredictability of action outcomes. The course will explore probabilistic techniques that allow robots to act reliably and exhibit a variety of different behaviors in spite of different sources of uncertainty. We will first cover algorithms for state estimation in both known and unknown environments. We will then explore functional aspects of robot's interaction with the world, such as the geometry of configuration spaces and manipulation planning in these spaces. We will wrap up the course by exploring the interplay of inference and planning and its applications in robot autonomy and human-robot interaction.

Learning Objectives: In this course, you will be introduced to probabilistic techniques that allow state estimation, manipulation and planning in robotics. By the end of this course you should be able to:

- demonstrate proficiency in the theoretical tools that support state estimation, manipulation and planning with sensor and modeling noise.
- implement these techniques and test them with real-world datasets.
- integrate your algorithms with state-of-the-art simulation environments
- critique a research paper's methods and analysis
- explain the computational and practical challenges of applying these techniques in real-world interaction settings and compare them in terms of robustness, scalability and performance.

Prerequisites: Students are required to have knowledge of **probability theory**, **linear algebra** and **calculus**. Programming knowledge of **Python** is also required.

Reading Material: There is no required textbook for this course. The lecture material is available online. Much of the lecture material is taken from these books:

- Russell, Stuart J., and Peter Norvig. Artificial intelligence: a modern approach. Pearson Education Limited, 2016. (RN)

- Sebastian Thrun,, Wolfram Burgard, and Dieter Fox. Probabilistic robotics. MIT press, 2005. (TBF)
- Howie Choset, Kevin M. Lynch, Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia E. Kavraki, and Sebastian Thrun. Principles of robot motion. (CL)
- Steven Lavalle. Planning algorithms. (LA)
- Sutton, Richard S., and Andrew G. Barto. Introduction to reinforcement learning, Second edition (SB).

The assignments and final exam will be based only on material covered in the lectures.

Grading:

Component	Percentage
Lab Assignments	35%
HW Assignments	25%
Final Exam	20%
Participation	10%
Scribing	10%

Assessment of Assignments

- **Lab Assignments**: There will be 3-4 lab assignments, which will involve applying the techniques taught in the classroom to robotic systems using real-world data. We will ask you to submit a report for each lab assignment showcasing your results.
- **Homework Assignments**: The homework assignments will have both theoretical and coding components that will exercise the techniques we will cover in the class and will help you prepare for the lab assignments.
- **Final Exam**: There will be a final exam on the material covered in the lectures and assignments. The exam will be both open book and open notes. No electronic devices will be allowed.
- **Participation**: You will get the most out of this class if you are active and engaged. This includes asking questions and participating in discussions

- **Scribing**: You will take turns compiling the lecture notes. The scribing will expand on the lecture notes and reading, and students will be expected to include figures and reference. Scribes should delived the notes within five days of the lecture for review.

Note: Regardless of the grading system, you are required to submit *all* homework assignments, lab assignments, take the final exam and regularly attend lectures to receive a passing grade for the class.

Tentative Schedule:

Date	Lecture	Topic	Assignment (Released)	Readings
Aug 26	1	Introduction		
Wed Aug 28	2	Matrix Algebra Refresher	HW1 (Math Fundamentals)	
Mon Sep 02		Labor Day (no class)		
Wed Sep 04	3	Probability Theory		
Mon Sep 09	4	Python / ROS Tutorial	Lab1	
Wed Sep 11	5	Bayesian Networks		RN Ch. 13-14
Mon Sep 16	6	Linear Dynamical Systems		
Wed Sep 18	7	Bayesian and Kalman Filters		TBF Ch. 2, 3.1-3.2.3
Mon Sep 23	8	EKF and Particle Filters	HW2 (KF/EKF)	TBF Ch. 3.3.1-3.3.3, 4.3.1-4.3.2
Wed Sep 25	9	Motion and Sensor Models		TBF Ch. 5.3.2, 5.4.2, 6.3.1, 6.6.2
Mon Sep 30	10	Localization and Mapping		TBF Ch. 7.4.1, 7.4.2, 7.5.1, 9.2 - excluding 9.2.1
Wed Oct 02	11	SLAM	Lab2 (Localization)	TBF 10.2.1, 10.2.2
Mon Oct 07	12	AIKIDO Tutorial		

Wed Oct 09	13	Guest Lecture (TBD)		
Mon Oct 14	14	Mathematical Programming		
Wed Oct 16	15	Configuration Spaces		CL 3.1,3.2, 3.5.1
Mon Oct 21	16	Kinematic Transformations	HW3 (FK / IK)	CL 3.6-3.8
Wed Oct 23	17	Combinatorial Motion Planning		CL 5.1.1, LA 6.2.2, LA 7.1.1
Mon Oct 28	18	Sampling-based Motion Planning I		CL 7.1.1, 7.2.2
Wed Oct 30	19	Sampling-based Motion Planning II	HW4 (RRT)	CL 7.3.3, LA 7.3.1
Mon Nov 04	20	Constraint-based Planning		Task Space Regions
Wed Nov 06	21	Guest Lecture (TBD)		
Mon Nov 11	22	Guest Lecture (TBD)	Lab 3 (Motion Planning)	
Wed Nov 13	23	Dynamics		
Mon Nov 18	24	Non-Linear Control		
Wed Nov 20	25	Data-Driven Manipulation	Lab 4 (Task Space Planning)	Learning with Human Adversaries
Mon Nov 25	26	Human-Robot Interaction		
Wed Nov 27		Thanksgiving (no class)		
Mon Dec 02	27	Recap I		
Wed Dec 04	28	Recap II		

Late Submission Policy: Each student will be granted 7 calendar days that they can use for late submission of the HW and the Labs without any penalty. We will not accept late assignments after the 7 days are spent.

Additional Policies: Unless you are assigned to compile lecture notes, please refrain from using laptops or other electronic devices during class

Statement on Academic Conduct and Support Systems

Academic Conduct:
Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct.

Support Systems:
Student Counseling Services (SCS) – (213) 740-7711 – 24/7 on call
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention. engemannshc.usc.edu/counseling

National Suicide Prevention Lifeline – 1 (800) 273-8255
Provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week. www.suicidepreventionlifeline.org

Relationship and Sexual Violence Prevention Services (RSVP) – (213) 740-4900 – 24/7 on call
Free and confidential therapy services, workshops, and training for situations related to gender-based harm. engemannshc.usc.edu/rsvp

Sexual Assault Resource Center
For more information about how to get help or help a survivor, rights, reporting options, and additional resources, visit the website: sarc.usc.edu

Office of Equity and Diversity (OED)/Title IX Compliance – (213) 740-5086
Works with faculty, staff, visitors, applicants, and students around issues of protected class. equity.usc.edu

Bias Assessment Response and Support
Incidents of bias, hate crimes and microaggressions need to be reported allowing for appropriate investigation and response. studentaffairs.usc.edu/bias-assessment-response-support

The Office of Disability Services and Programs

Provides certification for students with disabilities and helps arrange relevant accommodations. dsp.usc.edu

Student Support and Advocacy – (213) 821-4710
Assists students and families in resolving complex issues adversely affecting their success as a student EX: personal, financial, and academic. studentaffairs.usc.edu/ssa

Diversity at USC
Information on events, programs and training, the Diversity Task Force (including representatives for each school), chronology, participation, and various resources for students. diversity.usc.edu

USC Emergency Information
Provides safety and other updates, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible. emergency.usc.edu

USC Department of Public Safety – UPC: (213) 740-4321 – HSC: (323) 442-1000 – 24-hour emergency or to report a crime.
Provides overall safety to USC community. dps.usc.edu