Introduction to Robotics: Perception, Mechanics, Dynamics and Control

Fall 2021

Instructor:	Donghyun Kim	**Time:**	Tue Thur 4:00 – 5:15 PM
Email:	donghyunkim@cs.umass.edu	**Place:**	Marston Hall 132

TAs:

- Shifan Zhu (shifanzhu@umass.edu)
- Daniel Marew (dmarew@umass.edu)
- Komal Garg (komalpremcha@umass.edu)(Grader)

Office Hours:

- Wed 3:00 - 4:00 pm (LGRC 325)
- Fri 2:00 - 3:00 pm (LGRC 308)

Objectives: This class is designed as a first course in robotics. We will cover the basics of robotics including motor control, spatial representations, actuation, and machine learning in robotics. Students will build a dynamics simulation in order to reinforce the readings and the written exercises. Over the course of the semester, a library of hierarchical skills will be built to support an increasingly integrated robotic application.

Grading Policy: Homework (40%) and Quizzes (15%), Midterm 1 (20%), Midterm 2 (20%), Final Project(5%).

Late Policy: Assignments should be handed in by 11:50 PM on the posted due date. There will not be a penalty until the next morning (8:00 AM) but after that time, they are considered 1 day late. You will have four late days for every assignment with a penalty of 5% of your score for every late day. After four days, the assignment will receive a zero.

Class Policy:

- Regular attendance is essential and expected.

Academic Honesty: Lack of knowledge of the academic honesty policy is not a reasonable explanation for a violation.

Tentative Course Outline:

	Date	Lecture contents	Quiz	HW
Week 1	09/02 (Thu)	Do you like a robot? What's the robot and robotics research?	No; first week	HW#1 Robot definition/ github & matlab setting
Week 2	09/07 (Tue) 09/09 (Thu)	Review of Linear algebra and convex optimization 2D Kinematics: forward/inverse kinematics, Jacobian.	Q1. Linear algebra	HW#2 parallel linkage (due on Sunday night)
Week 3	09/14 (Tue) 09/16 (Thu)	Holonomic/ nonholonomic systems Spatial representation	Q2. 2 D.O.F planar manipulator kinematics	HW#3 Frame representation
Week 4	09/21 (Tue) 09/23 (Thu)	Spatial Kinematics Inverse Kinematics and Orientation in 3D space	Q3. Z- rotation orientation matrix	HW#4 3D open chain forward kinematics
Week 5	09/28 (Tue) 09/30 (Thu)	Dynamics Lagrangian dynamics 1	Q4. Relationship between SO(3), Quaternion, and Euler angle	HW#5 Planar openchain dynamics simulation
Week 6	10/05 (Tue) 10/07 (Thu)	Lagrangian dynamics 2 Operational space control	Q5. Multi-body dynamics	HW#6 OSC test and contact test
Week 7	10/12 (Tue) 10/14 (Thu)	Contact dynamics 1 Contact dynamics 2	Q6. Operational space control	No homework (Exam)
Week 8	10/19 (Tue) 10/21 (Thu)	Exam 1 Whole-Body Control	No quiz (after Exam)	HW#7 Contact implementation
Week 9	10/26 (Tue) 10/28 (Thu)	Feedback control, spring damper, Laplace transform Stability analysis	Q7. Gain margin vs phase margin	HW#8 whole-body control
Week 10	11/02 (Tue) 11/04 (Thu)	LQR Trajectory optimization 1	Q8. LQR	HW#9 LQR cart-pole
Week 11	11/09 (Tue) 11/11 (Thu)	Trajectory optimization 2 Veterans' Day	Q9. Trajectory optimization vs path planning	HW#10 Jump optimization
Week 12	11/16 (Tue) 11/18 (Thu)	Model predictive control Exam 2	Q10. A* explanation	No homework (Exam)
Week 13	11/23 (Tue) 11/25 (Thu)	Seminar (Prof. Sehoon Ha @ GATech) Thanksgiving	-	No homework. Thanksgiving!
Week 14	11/30 (Tue) 12/02 (Thu)	Reinforcement learning - overview Reinforcement learning - Software introduction and examples	-	HW#11 Installation of Raisim and example codes te
Week 15	12/07 (Tue)	Reinforcement learning - Recent research	-	**Final Project due 12/16**