ME 221: Kinematics and Dynamics of Robots

Department of Mechanical Engineering
University of California, Riverside
Fall 2022
Syllabus v1, September 22, 2022

Instructor: Jonathan Realmuto
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Department of Mechanical Engineering
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Time and Location: T/Th 5:00pm–6:50pm, HMNSS 1502
Office Hours: by appointment
Website: https://intra.engr.ucr.edu/~jrealmuto/courses/me221-f22/

References Materials: *Theory of Applied Robotics*
Reza N. Jazar
(online edition available through the UCR library)

Modern Robotics
Kevin M. Lynch and Frank C. Park

A Mathematical Introduction to Robotic Manipulation
Richard M. Murray, Zexiang Li, and S. Shankar Sastry

Springer Handbook of Robotics
Editors: Bruno Siciliano and Oussama Khatib

Summary

This course provides an overview of kinematics, dynamics, and basic control for robotic mechanism. The aim is to provide the fundamental knowledge and tools needed for modeling, design, planning, and control of robot systems. The material treated represents a survey of relevant methods and results from geometry, kinematics, statics, dynamics, and control. Some applications will also be introduced, including walking robots, parallel robots, compliant robots, and physical human-robot interaction.

Objectives

By the end of the course, you should be able to:

- Provide a mathematical and geometrical description of robotic manipulators
- Derive from first principles robot dynamics and know how to simulate them
- Understand basic robot control architectures
- Articulate scientific results to your peers

Prerequisites

This course assumes an undergraduate-level training in dynamics and controls. The assumption is that students are, at a minimum, familiar and comfortable with matrix algebra and differential equations. Familiarity with a numeric computing platform, like MATLAB or Python, is required.

Coursework

There will be four main components:

I. Homework. Weekly homework assignments will be assigned throughout the quarter. Students are encouraged to work together, however, each student must turn in their own assignment. Late homework will be accepted with a 10% grade penalty per day.

II. Paper review presentations. Each student will be assigned academic papers to review, present, and discuss with the class. Each presentation should follow the following format:

(a) Title slide: include authors names and institutions, the presenter's name, and date

(b) Summary slide: a succinct summary of the paper's main contributions

(c) Background slide(s): summarize relevant background or history of the problem to be solved

(d) Method slide(s): summary of the methods used

(e) Results slide(s): details of the paper's main results including supporting figures

(f) Strengths slide(s): note at least one major strength of the paper

(g) Weakness slide(s): note at least one major weakness and how it might be improved

The presenter will follow up the presentation by leading a brief in-class discussion. To do this, prepare a few (2-3) non-trivial questions that result from attempting to understand the material, its broader implications, and connections to other work and course material. The whole presentation, including in-class discussion, should take approximately 30 minutes.

III. Course project. The course project should align with your thesis research project. It will involve the skills and tools developed through homework, lectures, and exams. It includes three deliverables: the proposal, final presentation, and report.

IV. Midterm and Final Both midterm and final are required and designed to test your knowledge of the course material. The final will only cover material after the midterm.

Grading

Homework:	25 %
Paper presentation:	10 %
Participation:	5 %
Project:	30 %
Midterm:	15 %
Final:	15 %

Grading Scheme

A+	100 - 97%	C+	$<$ 80 - 77%
A	$<$ 97 - 94%	C	$<$ 77 - 74%
A-	$<$ 94 - 90%	C-	$<$ 74 - 70%
B+	$<$ 90 - 87%	D+	$<$ 70 - 67%
B	$<$ 87 - 84%	D	$<$ 67 - 64%
B-	$<$ 84 - 80%	D-	$<$ 64 - 60%
		F	$<$ 60 - 0%

Tentative schedule

	Date	Topic	Homework/Project
Week 0	9/22	Course overview	
Week 1	9/27	Rotation and Orientation	
	9/29	Motion Kinematics	
Week 2	10/4	Forward Kinematics	
	10/6	Forward Kinematics	HW1 due
Week 3	10/11	Inverse Kinematics	
	10/13	Inverse Kinematics	
Week 4	10/18	Velocity Kinematics	
	10/20	Review	HW2 due & Proposal due
Week 5	10/25	*Midterm*	
	10/27	Jacobian	
Week 6	11/1	Motion Dynamics	
	11/3	Robot Dynamics	HW3 due
Week 7	11/8	Robot Control	
	11/10	Trajectory Planning	
Week 8	11/15	Trajectory Planning	
	11/17	Advance Control	HW 4 due
Week 9	11/22	Advance Topic (tbd)	
	11/24	Thanksgiving Break	
Week 10	11/29	Office Hours / Review	
	12/1	*Project final presentation*	HW 5 due
Final	12/3	*Saturday* 8am - 11am	Project Report due