MEC 529 - Introduction to Robotics: Theory and Applications

Instructor: Nilanjan Chakraborty

Contact Information

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Lecture Hours

Time: Tuesday, 1 : 00 PM - 3 : 50 PM.
Location: SOCBEHAV SCI S328.

Office Hours

Location: Heavy Engineering 212
Time: Tuesday, 11 : 00 AM - 12 : 30 PM; Thursday, 2 : 30 PM - 4 : 00 PM.
Alternate Times: Please send me an email to make an appointment.

Course Description

This course will cover fundamental concepts in Robotics useful for applications ranging from traditional manipulators in industrial robotics to unmanned aereal robots for environmental sensing and cargo transport. This course is divided into approximately three parts. In the first part of the course, basic concepts will be discussed, including direct and inverse position kinematics and differential kinematics, dynamics, feedback and feedforward control, and state estimation. The above concepts will be discussed and illustrated within the context of robotic manipulators. The second part of the course will focus on applying the knowledge from the initial lectures to other types of robots including wheeled robots, aereal robots, robotic hands, and legged robots. The third part of the course will discuss motion planning, sensing, and actuation in different robotic systems. If time permits, we will also spend some time on studying issues that arise in moving from single robot systems to coordinating multi-robot systems. This course is intended for graduate students with interests in Robotics and Artificial Intelligence. Advanced undergraduates with a demonstrated interest in Robotics are also welcome. Prerequisites include a foundation in Linear Algebra and Calculus, and the ability to program in Matlab. Depending on the class needs I will provide a primer on Matlab and Latex.

Books

- J. J. Craig, *Introduction to Robotics: Mechanics and Control*, 3rd Edition, Addison-Wesley, 2003.
- Richard M. Murray, Zexiang Li and S. Shankar Sastry, *A Mathematical Introduction to Robotic Manipulation*, CRC Press.
- S. Lavalle, *Robot Motion Planning*, Cambridge University Press.

Assignments, Exams, and Projects

- **Homeworks**: There will be 6 homeworks. You will have about $1-2$ weeks to complete a homework. Homeworks will be due in class. The homeworks will include Matlab coding. You are allowed to discuss with your colleagues but you have to submit your individual work. Any discussion or help that you have taken from your colleagues or other sources should be acknowledged. In other words, you should write the name of the persons you have worked with and also state explicitly the kind of help you have received.
- **Paper Critique**: There will also be one paper review report that you have to submit. You have to select one paper from a list of papers that I will provide (or you can choose your own paper based on your final project) and you have to write a critical review of the paper. You will get one week for the paper review.
- **Lecture Scribing**: You will also have to serve as a scribe for one lecture note. This will be done in groups of two. Latex support files will be provided for scribing.
- **Midterm Exam**: There will be one take home midterm exam. The exam will be open book, open notes. You will have approximately one week to complete your exam. You are not allowed to consult with your colleagues for the exam.
- **Final Project and Presentation**: There will be one final project that will be done in groups of 2 to 3 students. You have to do one presentation and two reports for the final project. The first report will be a project proposal where you will describe the problem you want to solve and what are your plans for solving the problem. The final report and presentation will be a comprehensive description of your work. The reports are to be written using Latex. I will provide the supporting style files.

Grading Breakdown and Policy

Your overall grade will be based on your performance in all the class work mentioned above. The weight distribution on grades for the different components are given below.

- 6 Homeworks (25%).
- 1 Take Home Midterm Exam (30%).
- 1 Paper Critique (10%).
- Scribing 1 Lecture (5%).
- Final Project and Project Presentation (30%).

The GRADING SCALE will be an accumulation of your course work, as follows (there will probably be no curves): A (100-90), A- (89-85), B+ (84-80), B (79-75), B- (74-70), C+ (69-65), C (60-64), F (59 or below).

Late Assignment Policy: Assignments are due in class unless otherwise stated or you have made prior arrangements with me. You are allowed at most two late days for each homework or paper critique. If you submit your homework late you will be penalized 20% of the points. Assignments will not be accepted after the late days expire. No late submission is allowed for the mid-term exam or the final project report.

Collaboration Policy: You are allowed and encouraged to collaborate with your fellow students on home works. However, you are required to turn in your own work and you should not copy the work of another person. Any collaboration or help should always be acknowledged explicitly. **No collaboration is allowed** on the take home midterm exam.

Assignment and Exam Schedule (Tentative)

Name	Date Available	Due Date
Assignment 1	**2\7\2017**	**2\14\2017**
Assignment 2	**2\14\2017**	**2\21\2017**
Assignment 3	**2\21\2017**	**2\28\2017**
Assignment 4	**2\28\2017**	**3\7\2017**
Review Report	**3\7\2017**	**03\21\2017**
Take Home Exam	**3\28\2017** (6 : 00 PM)	**4\03\2017** (6 : 00 PM)
Assignment 5	**4\04\2017**	**4\18\2017**
Assignment 6	**4\18\2017**	**4\25\2017**
Final Project Presentation	NA	**5\02\2017**
Final Project Report	NA	**5\06\2017**

Course Learning Objectives

Upon completion of this course students will be able to

- Convert description of points and vectors among different reference frames.
- Know about different representations of configuration of a rigid body and how to convert between them.
- Solve direct and inverse position and velocity kinematics problem of a manipulator.
- Form a manipulator Jacobian and use it in singularity analysis and control.
- Form a grasp Jacobian and use it in grasp analysis.
- Know how to write down the equations of motion of a manipulator using Lagrangean mechanics.
- Understand the different feedback control schemes for controlling a manipulator.
- Write the kinematics of wheeled robots and use it for solving mobile robot localization/control problems.
- Know basic motion planning techniques for manipulators and mobile robots.
- Know how to formulate and solve a robot control problem.
- Implement kinematic analysis, dynamic analysis, and control algorithms for manipulators in computer programs.

Lecture Topics (Tentative)

1. Introduction, Overview of course with a simple example.
2. Basics of Rigid Body Kinematics
3. Direct Position Kinematics of robotic systems.
4. Direct Velocity Kinematics of robotic systems.
5. Inverse Position and Velocity Kinematics of robotic systems.

6. Robotic Grasping and Manipulation.
7. Dynamics and Inverse Dynamics of robotic systems.
8. Feedback Control of Manipulators.
9. Mobile Robots - Kinematics, Dynamics and Control (wheeled robots and flying robots).
10. State Estimation in Mobile Robots (Localization).
11. Determenistic Techniques for Robot Motion Planning.
12. Randomized Techniques for Robot Motion Planning.
13. Control of Robots with Uncertain Parameters.

Disability Support Services

Americans with Disabilities Act: If you have a physical, psychological, medical or learning disability that may impact your course work, please contact Disability Support Services, ECC(Educational Communications Center) Building, Room 128, (631)632-6748. They will determine with you what accommodations, if any, are necessary and appropriate. All information and documentation is confidential. `http://studentaffairs.stonybrook.edu/dss/index.shtml`.

Academic Integrity Statement

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty are required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Technology & Management, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including categories of academic dishonesty, please refer to the academic judiciary website at `http://www.stonybrook.edu/uaa/academicjudiciary/`

Critical Incident Management

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of Judicial Affairs any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Faculty in the HSC Schools and the School of Medicine are required to follow their school-specific procedures.