USC Viterbi School of Engineering

EE 599: Robotic Mobility

Units: 4
Term: Fall 2022
Day: Tu, Th
Time: 2-4pm

Instructor: Feifei Qian
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Instructor Webpage:
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Course Webpage:

Teaching Assistant: Xingjue Liao (lab related questions), Haodi Hu (assignments related questions), Shipeng Liu (project related questions)
Office: RTH 324 (Liao, Hu), EEB B16 (Liu)
Office Hours: Liao: Friday 12-1pm; Hu: Monday 3-4pm; Liu: Wednesday 2-3pm.
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Course Description

Applications involving mobile robots are becoming an increasingly important part of society and industry, including delivery, search and rescue, healthcare, and extraterrestrial explorations. How to achieve high mobility in the real world has been a key topic in robotics, and requires an integration of knowledge and skills from different fields including morphology design, kinematics control, dynamics modelling, sensing information analysis, and motion planning. This specialized course will combine lectures, student presentations, and hands-on lab projects to provide an overview of robotic locomotion control and analysis, and expose students to the latest challenges and progress associated with robotic mobility in complex environments.

Learning Objectives

1. Students will be introduced to different types of locomotion, abstract models of locomotion dynamics, as well as state-of-the-art implementation of mobile robotic platforms.
2. Students will learn methods and tools for robot gait design and generation, movement analysis, terrain modelling, and dynamics template composition.
3. Students will be equipped with experimental skills to perform actuator control, gait programming, kinematics control, and analysis of locomotion dynamics.

Required Readings and Supplementary Materials

Textbook: There will be no required textbook. Lectures will cover selected material drawn from some of the additional texts listed below and relevant research articles.
Additional recommended text:

1. Sharbafi, Maziar Ahmad, and André Seyfarth, eds. *Bioinspired legged locomotion: models, concepts, control and applications*. Butterworth-Heinemann, 2017.

2. Lynch, Kevin M., and Frank C. Park. *Modern Robotics*. Cambridge University Press, 2017.
3. Choset, Howie M., et al. *Principles of robot motion: theory, algorithms, and implementation*. MIT press, 2005.

Description and Assessment of Assignments

- ***Homework*:** Students will be assigned three homeworks throughout the semester. Homework will consist of solving problems based on lecture topics. Homeworks are to be submitted in class on the due date. Late homeworks will not be accepted unless prior approval for late submission has been obtained.
- ***Paper Reviews and Presentations*** Each student will select two topics of interest during the first week, give a 10-15 min in-class presentation on one research paper from each category and lead class discussion.
- ***Lab Project*** There will be hands-on lab sessions and final project. Students will work individually as well as in groups to complete lab projects.

Grading Breakdown

Assignment	**Points**	**% of Grade**
Homework	25	25%
Paper Presentations	10	10%
Lab assignments	25	25%
Project demonstration (team grade)	15	15%
Final presentation and report	25	25%
TOTAL	**100**	**100%**

Tentative Course Schedule (may subject to change)

	Topics/Daily Activities	**Deliverable/ Due Dates**
Week 1 (8/22-8/27)	Overview. Structure of the course; Topics to be covered; Presentation topics; Lab and project overview	Select paper presentation topics Lab 0: introduction and setup
Week 2 (8/29-9/2)	Types of mobility: walking, running, hopping, climbing, crawling, digging, brachiating, burrowing, swimming, flying. Robotic gait generation and control	Lab 1 assigned.
Week 3 (9/5-9/9) Labor day 9/5	Kinematics control Part 1: Forward kinematics; Jacobian.	HW1 assigned
Week 4 (9/12-9/16)	Kinematics control Part 2: Inverse kinematics.	Lab 1 due. Lab 2 assigned
Week 5 (9/19-9/23)	Motion planning: geometric mechanics.	HW1 due. HW2 assigned.
Week 6 (9/26-9/30)	Dynamics Part 1: Templates and anchors. Dynamics templates of walking and running: Inverted pendulum; spring-loaded inverted pendulum; rimless wheel.	Lab 2 due. Lab 3 assigned
Week 7 (10/3-10/7)	Dynamics Part 2: Lagrangian, return map analysis	HW2 due. HW3 assigned

		Project announced
Week 8 (10/10-10/14) Fall break 10/13-10/14	Dynamics Part 3: case study of single leg hopper	Lab 3 due
Week 9 (10/17-10/21)	Locomotion control architecture: Feedforward vs. feedback; Centralized vs. decentralized.	HW3 due Project's team selection and environment selection due
Week 10 (10/24-10/28)	Terrain adaptation Part 1: Effect of terrain properties on robot mobility: hard vs compliance surface, uneven terrain, cluttered	Project's robot design due
Week 11 (10/31-11/4)	Terrain adaptation Part 2: Effect of terrain properties on robot mobility: soft and deformable surfaces	Project's experiment design due
Week 12 (11/7-11/11)	Terrain adaptation Part 3: Kinematics and dynamics of non-legged mobile robots	
Week 13 (11/14-11/18)	Perception for mobility	Project's progress report due
Week 14 (11/21-11/25) (Thanksgiving 11/23-11/27)	Effect of morphology design on robot mobility	
Week 15 (11/28-12/2) Last class 12/2	**Project demo and presentations**	Final project reports due
FINAL		

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" https://policy.usc.edu/student/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.

Discrimination, sexual assault, intimate partner violence, stalking, and harassment are prohibited by the university. You are encouraged to report all incidents to the *Office of Equity and Diversity*/*Title IX Office* http://equity.usc.edu and/or to the *Department of Public Safety* http://dps.usc.edu. This is important for the health and safety of the whole USC community. Faculty and staff must report any information regarding an incident to the Title IX Coordinator who will provide outreach and information to the affected party. The sexual assault resource center webpage http://sarc.usc.edu fully describes reporting options. Relationship and Sexual Violence Services https://engemannshc.usc.edu/rsvp provides 24/7 confidential support.

Support Systems

A number of USC's schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the *American Language Institute* http://ali.usc.edu, which sponsors courses and workshops specifically for international graduate students. *The Office of Disability Services and Programs* http://dsp.usc.edu provides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, *USC Emergency Information* http://emergency.usc.edu will provide safety and other updates, including ways in which instruction will be continued by means of Blackboard, teleconferencing, and other technology.