EE 599: Robotic Mobility
Units: 4
Fall2023—Tu/Th—2-4pm:
Location: EEB B18
Instructor: Feifei Qian
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Office Hours: Tuesday 4-5pm
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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 modeling, 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. This course is primarily oriented towards 1st and 2nd year PhD students in ECE, AME, CS, and other relevant engineering programs.

Learning Objectives
By the end of this course, students will be able to
1. implement state-of-the-art methods to design and optimize robot gaits, model compex terrains, and derive locomotion dynamics models.
2. obtain hands-on skills in actuator control, gait programming, kinematics control, and locomotion analysis
3. identify and investigate the latest robotics mobility challenges, and write conference paper style manuscripts to report scientific discoveries.

Prerequisite(s): N/A
Co-Requisite(s): N/A
Concurrent Enrollment: N/A
Recommended Preparation: Students will be assumed to have basic programming skills. Hands-on labs will use Arduino, hence familiarity with microcontrollers will be helpful (but not required).

Course Notes
The course will be letter grade. Blackboard will be used to post assignments and release grades. Lecture slides (without notes) will be posted on Blackboard.

Technological Proficiency and Hardware/Software Required
Hands-on labs require programming in Arduino IDE. Data analysis and plotting require Matlab or Python.

Required Readings and Supplementary Materials

There will be no required textbook. Lectures will cover selected material drawn from the texts listed in "Optional Readings and Supplementary Materials" as well as relevant research articles.

Optional Readings and Supplementary Materials

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 two homework. Homework will consist of solving problems based on lecture topics.
- *Paper Reviews and Presentations* Each student will select two topics of interest during the first week. For each category, each student will select a date and time to give a 10 min in-class presentation on one research paper, and lead class discussion.
- *Hands-on labs and team project* There will be 3 hands-on lab sessions and 1 final project. Students will work individually as well as in groups to complete these hands-on assignments. For the project, students will form a team of 3. Each team will select one mobility challenge task to perform research investigation, and write a conference paper style report to describe the results and interpretations.

Grading Breakdown

Assessment Tool (assignments)	Points	% of Grade
Homework	20	20
Hands-on labs	30	30
Paper presentation	10	10
Project	40	40
TOTAL	100	100

Grading Scale

Course final grades will be determined using the following scale. A curve may be applied if the average is significantly higher or lower than expected.

Letter grade	Corresponding numerical point range
A	95-100
A-	90-94
B+	87-89
B	83-86
B-	80-82
C+	77-79
C	73-76
C-	70-72
D+	67-69
D	63-66
D-	60-62
F	59 and below

Assignment Submission Policy

Assignments are to be submitted in class or through email on the due date. Late homeworks will not be accepted unless prior approval for late submission has been obtained.

Grading Timeline

Grading and feedback will usually be released through Blackboard within 2 weeks of submission due date.

Academic Integrity

The University of Southern California is foremost a learning community committed to fostering successful scholars and researchers dedicated to the pursuit of knowledge and the transmission of ideas. Academic misconduct is in contrast to the university's mission to educate students through a broad array of first-rank academic, professional, and extracurricular programs and includes any act of dishonesty in the submission of academic work (either in draft or final form).

This course will follow the expectations for academic integrity as stated in the USC Student Handbook. All students are expected to submit assignments that are original work and prepared specifically for the course/section in this academic term. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s). Students suspected of engaging in academic misconduct will be reported to the Office of Academic Integrity.

Other violations of academic misconduct include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

If found responsible for an academic violation, students may be assigned university outcomes, such as suspension or expulsion from the university, and grade penalties, such as an "F" grade on the assignment, exam, and/or in the course.

For more information about academic integrity see the student handbook or the Office of Academic Integrity's website, and university policies on Research and Scholarship Misconduct.

Course Content Distribution and Synchronous Session Recordings Policies

USC has policies that prohibit recording and distribution of any synchronous and asynchronous course content outside of the learning environment.

Recording a university class without the express permission of the instructor and announcement to the class, or unless conducted pursuant to an Office of Student Accessibility Services (OSAS) accommodation. Recording can inhibit free discussion in the future, and thus infringe on the academic freedom of other students as well as the instructor. (Living our Unifying Values: The USC Student Handbook, page 13).

Distribution or use of notes, recordings, exams, or other intellectual property, based on university classes or lectures without the express permission of the instructor for purposes other than individual or group study. This includes but is not limited to providing materials for distribution by services publishing course materials. This restriction on unauthorized use also applies to all information, which had been distributed to students or in any way had been displayed for use in relationship to the class, whether obtained in class, via email, on the internet, or via any other media. (Living our Unifying Values: The USC Student Handbook, page 13).

Course Schedule

	Topics/Daily Activities	Readings/Preparation	Deliverables
Week 1	Overview. Structure of the course; Topics to be covered; Presentation topics; Lab and project overview	Select paper presentation topics	Lab 0 assigned (mainly HW/SW setup, no submission required)
Week 2	Types of mobility: walking, running, hopping, climbing, crawling, digging, brachiating, burrowing, swimming, flying. Robotic gait generation and control (legged)		Lab 1 assigned
Week 3	Robot gait generation and control (non-legged); Kinematics control Part 1: Forward kinematics.		HW1 assigned
Week 4	Kinematics control Part 2: Inverse kinematics.		Lab 1 due Lab 2 assigned
Week 5	Motion planning: geometric mechanics.		HW1 due
Week 6	Dynamics Part 1: Templates and anchors. Dynamics of walking: Inverted pendulum		Lab 2 due Lab 3 assigned
Week 7	Dynamics Part 2: Rimless wheel Dynamics of running: SLIP model		Project assigned
Week 8	Raibert's hopper (vertical hopper control)		Lab 3 due HW2 assigned
Week 9	Planar hopper control		Project proposal due
Week 10	Adaptation on soft terrain (legged)		HW2 due
Week 11	Adaptation on soft terrain (non-legged)		Project experiment plan due
Week 12	Adaptation on rough terrain (legged)		
Week 13	Adaptation on rough terrain (non-legged)		Progress report due
Week 14	Putting it all together: locomotion architecture; sensory feedback; where to go from here		
Week 15	Project demo and presentation		Project report due
FINAL	N/A	N/A	

Statement on Academic Conduct and Support Systems

Academic Integrity:
The University of Southern California is a learning community committed to developing successful scholars and researchers dedicated to the pursuit of knowledge and the dissemination of ideas. Academic misconduct, which includes any act of dishonesty in the production or submission of academic work, comprises the integrity of the person who commits the act and can impugn the perceived integrity of the entire university community. It stands in opposition to the university's mission to research, educate, and contribute productively to our community and the world.

All students are expected to submit assignments that represent their own original work, and that have been prepared specifically for the course or section for which they have been submitted. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s).

Other violations of academic integrity include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), collusion, knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university. All incidences of academic misconduct will be reported to the Office of Academic Integrity and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see the student handbook or the Office of Academic Integrity's website, and university policies on Research and Scholarship Misconduct.

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment, or what information requires citation and/or attribution.

Students and Disability Accommodations:

USC welcomes students with disabilities into all of the University's educational programs. The Office of Student Accessibility Services (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Support Systems:

Counseling and Mental Health - *(213) 740-9355 – 24/7 on call*
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

988 Suicide and Crisis Lifeline - *988 for both calls and text messages – 24/7 on call*
The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline is comprised of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services

(though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

Relationship and Sexual Violence Prevention Services (RSVP) - *(213) 740-9355(WELL) – 24/7 on call*
Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

Office for Equity, Equal Opportunity, and Title IX (EEO-TIX) - *(213) 740-5086*
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment - *(213) 740-5086 or (213) 821-8298*
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

The Office of Student Accessibility Services (OSAS) - *(213) 740-0776*
OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

USC Campus Support and Intervention - *(213) 740-0411*
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity, Equity and Inclusion - *(213) 740-2101*
Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - *UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call*
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - *UPC: (213) 740-6000, HSC: (323) 442-1200 – 24/7 on call*
Non-emergency assistance or information.

Office of the Ombuds - *(213) 821-9556 (UPC) / (323-442-0382 (HSC)*
A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

Occupational Therapy Faculty Practice - *(323) 442-2850 or* otfp@med.usc.edu
Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.