Robot Localization and Mapping (16-833), Fall 2024

Days Monday and Wednesday
Time 12:30pm - 1:50pm
Room NSH 1305
Lecturer Michael Kaess (kaess@cmu.edu)
TAs Shibo Zhao (shiboz@andrew.cmu.edu),
Tianxiang Lin (tianxian@andrew.cmu.edu)
Zoom Link lectures: https://cmu.zoom.us/j/99562219197?pwd=KS8azS7WRmrgk2lWip7bAvauDX8K7U.1
Piazza discussions: https://piazza.com/cmu/fall2024/16833a
Canvas slides, recorded lectures, grades

Course Description

Robot localization and mapping are fundamental capabilities for mobile robots operating in the real world. Even more challenging than these individual problems is their combination: simultaneous localization and mapping (SLAM). Robust and scalable solutions are needed that can handle the uncertainty inherent in sensor measurements, while providing localization and map estimates in real-time. We will explore suitable efficient probabilistic inference algorithms at the intersection of linear algebra and probabilistic graphical models. We will also explore some state-of-the-art systems.

Schedule 11/3/2024

Date	Topic	Lecturer	Assignments
Aug 26	L01: Introduction	Michael	
Aug 28	L02: Probability Rev., Expectations and Covariances	Michael	
Sep 02	LABOR DAY	-	
Sep 04	L03: Bayes Filter	Michael	
Sep 09	L04: Particle Filter	Monty Abello	Sep 09: HW1 out
Sep 11	L05: Monte Carlo Localization	Monty Abello	
Sep 16	L06: Normal Distribution	Michael	
Sep 25	L07: Kalman Filter	Michael	
Sep 27	L08: Kalman Filter (2)	Michael	
Sep 30	L09: Extended Kalman Filter (EKF) / UKF	Michael	Sep 27: HW1 due, HW2 out
Oct 02	L10: SLAM and Least-Squares	Michael	
Oct 04	L11: Least-Squares	Michael	
Oct 07	L12: Sparse Least-Squares	Michael	
Oct 09	L13: Nonlinear Least-Squares, LM, PDL	Michael	Oct 11: HW3 out
Oct 14	FALL BREAK	-	
Oct 16	FALL BREAK	-	
Oct 21	L14: Rotations and Manifolds	Michael	Oct 21: HW2 due
Oct 23	L15: Inertial Navigation	Michael	Oct 25: project proposal
Oct 28	L16: Sequential Estimation	Michael	
Oct 30	L17: ORB-SLAM/VLOAM	Dan McGann	reading assignment
Nov 04	L18: Inference in Graphical Models	Michael	
Nov 06	L19: KinectFusion/NeRF	Shibo Zhao	Nov 8: HW3 due, HW4 out
Nov 11	L20: Bayes Tree	Michael	
Nov 13	L21: Bayes Tree (2)	Michael	Nov 15: project midterm
Nov 18	L22: Incremental Nonlinear Least-Squares	Michael	
Nov 20	L23: Data Association	Michael	Nov 22: HW4 due
Nov 25	L24: Occupancy Grid Maps	Michael	
Nov 27	THANKSGIVING	-	
Dec 02	Project Presentations	class	Dec 2: presentation slides
Dec 04	Project Presentations	class	Dec 11: final report due

Integrity

All encouraged to work together BUT you must do your own work (code and write up). If you work with someone, please include their name in your write up and inside any code that has been discussed. If we find highly identical write-ups or code without proper accreditation of collaborators, we will take action according to university policies, i.e. you will likely fail the course.

Grading

- 60% Homeworks (15% each)
- 10% Participation
- 30% Course Project

Late Day Policy

- 4 flexible late days to push deadlines back
- Before deadline 100% credit
- Up to 48 hours after deadline 50%
- After 48 hours 0% (you must submit something)

Learning Outcomes

- Implement an extended Kalman filter in the context of robot localization and mapping
- Derive and apply rigid body transformations
- Derive the analytical form of motion and measurement models
- Formulate state estimation problems as graphical models such as factor graphs
- Implement linear and nonlinear least-squares solvers for the simultaneous localization and mapping problem

Health

Take care of yourself. Do your best to maintain a healthy lifestyle this semester by eating well, exercising, avoiding drugs and alcohol, getting enough sleep and taking some time to relax. This will help you achieve your goals and cope with stress.

All of us benefit from support during times of struggle. You are not alone. There are many helpful resources available on campus and an important part of the college experience is learning how to ask for help. Asking for support sooner rather than later is often helpful.

If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support. Counseling and Psychological Services (CaPS) is here to help: call 412-268-2922 and visit their website at `http://www.cmu.edu/counseling/`. Consider reaching out to a friend, faculty, or family member you trust for help getting connected to the support that can help.

If you or someone you know is feeling suicidal or in danger of self-harm, call someone immediately, day or night:

- CaPS: 412-268-2922
- Re:solve Crisis Network: 888-796-8226

If the situation is life threatening, call the police:

- On campus: CMU Police: 412-268-2323
- Off campus: 911

If you have questions about this or your coursework, please let one of us know.