CS 733/833 Intro to Mobile Robotics

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Course Description

This course will introduce the foundational theory and practices in mobile robotics. The following topics will be covered

1. Robot kinematics: Matrix Algebra, coordinate transformation, wheeled locomotion
2. Common sensors: odometry, sonar, laser, depth, camera, and sensor processing
3. Probability theory: Axioms, Discrete and continuous random variables, Joint probability, Bayes theorem, Normal distribution and its properties
4. Robot navigation: Obstacle avoidance, path planning,
5. Robot localization: Kalman filter and particle filter for localization
6. Simultaneous localization and Mapping (SLAM)

Laboratory sessions is directed toward learning the Robot Operating System (ROS), understanding robot kinematics and sensor data.

Assignments, Exams, Project: There will be seven quizzes, one final exam, and four labs. Lab: 25%; Theory: 75%

Labs: Lab grade will be based on lab assignments, reports, and performance in the lab.

Grades:

Seven Quizzes: 50%

Four Lab Assignments: 20%

Final Exam: 30%

Programming: Python and ROS.

Reference: The primary textbook for this course is "Introduction to Autonomous Mobile Robots," by R. Siegwart, I. R. Nourbakhsh, MIT Press, 2011. The e-book is available at UNH library. Some materials covered in lectures are from the following books (all available in the library):

- Probabilistic Robotics, by S. Thrun, W. Burgard, and D. Fox, The MIT Press, 2005
- Principles of Robot Motion, by H. Choset, K. M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki and S. Thrun, The MIT Press, 2005
- Introduction to AI Robotics, by R. R. Murphy, The MIT Press, 2000

A Tentative Schedule

	Event	**Date**	Topic	Out/Due
Week 1	Lecture 1	August 29	Course and people Introduction	
	Lecture 2	August 31	Linear Algebra (LA) basics	
	No lab			
Week 2	Labor Day	September 5	No Classes	
	Lecture 3	September 7	Transformation matrix (TM) I	
	Lab 1	September 9	**Introduction to Lab**	Lab 1 out
Week 3	Lecture 4	September 12	Transformation matrix II	
	Lecture 5	September 14	Robot Kinematics I: Fundamentals of locomotion, wheel geometry and kinematic constraints	**Q1 (LA and TM)**
	Lab 1	September 9	**Introduction to ROS**	
Week 4	Lecture 6	September 19	Robot Kinematics II: ICR, maneuverability, steerability, Holonomic constraints	
	Lecture 7	September 21	No class: Momotaz @ NSF meeting	
	Lab 2	September 23	**Introduction to ROS**	Lab 1 due @5:00pm
Week 5	Lecture 8	September 26	Robot Kinematics III: Differential drive robot ~~Sensors for mobile robots~~	
	Lecture 9	September 28	Motion Planning (MP): Configuration space, Path Planning: Combinatorial (visibility graph, cell decomposition, Voronoi diagram)	
	Lab 2	**September 30**	**Introduction to RViz, Gazebo**	**Lab 2 out**
Week6	Lecture 10	October 3	A* search algorithm	Q2 (Kinematics)
	Lecture 11	October 5	A* search example, Obstacle Avoidance (OA): Bug and VFH	
	Lab 2	**October 7**	**Introduction to RViz, Gazebo**	
Week 7		October 10	Mid-semester break (No Class)	
	Lecture 12	October 12	Potential field (PF) for path planning and OA	**Q3(MP,A*, sensor, OA)**
	Pre-Lab 3	October 14	**Writing a ROS Node for TurtleBot**	**Lab 2 due Pre-lab3 out**
Week 8	Lecture 13	October 17	Potential field for OA and MP	
	Lecture 14	October 19	Review of Probability theory I	
	Pre-Lab 3	**October 21**	**Writing a ROS Node for TurtleBot**	**practice**

Week 9	Lecture 15	October 24	Bayesian Probability and occupancy grid map updating	
	Lecture 16	October 26	Robot Navigation I (Basics) ** **Understanding Sensor Data** **	
	Lab 3	October 28	**Mobile Robot Kinematics and Odometry**	**Pre-Lab3 due** **Lab3 out**
Week 10	Lecture 17	October 31	Robot Navigation I (contd)	**Q4 (PF+ Probability)**
	Lecture 18	November 2	Robot Localization I: Markov	
	Lab 3	November 4	**Mobile Robot Kinematics and Odometry**	
Week 11	Lecture 19	November 7	Robot Localization II: Markov	
	Lecture 20	November 9	Robot Navigation I: Kalman Filter	**Q5: (Mapping, navigation, Markov)**
		November 11	**Veterans days UNH Closed**	
Week 12	Lecture 21	November 14	Robot Navigation II: Kalman Filter	
	Lecture 22	November 16	Robot Navigation III: Kalman Filter	
	Lab 3	November 18	**Mobile Robot Kinematics and Odometry**	**Lab 3 due**
Week 13	Lecture 23	November 21	Robot Navigation IV: Particle Filter	
		November 23	**Thanksgiving, No Class**	
		November 25	**Thanksgiving, No Lab**	
Week 14	Lecture 24	November 28	Robot Navigation IV: Particle Filter	**Q6 (KF)**
	Lecture 25	November 30	Robot Navigation V: Particle Filter	
	Lab3	**December 2**	**Real robot demo by TA**	**Optional**
Week 15	Lecture 26	December 5	SLAM	
	Lecture 27	December 7	SLAM	**Q7(PF)**
		December 9	**No Lab**	
Week 16	Lecture 28	December 12	Exam review	
Final Exam: TBD (Between Dec 13 and Dec 20)				

This schedule will be adjusted frequently based on the progress of the class. The instructor reserves all rights to change the lecture topics, exam dates, and due dates for assignments and labs during the semester.

Q: quiz (20-40 minutes, 2-4 questions)