Technical University of Crete
School of Electrical and Computer Engineering

Graduate Course on Probabilistic Robotics

TUC ECE INF 909 | **Course Syllabus** | Winter Semester 2024

Lectures: Thursday, 15:00–17:00, Room 145.P58 (Science Building, 2nd floor)
Friday, 17:00–19:00, Room 145.P42 (Science Building, 2nd floor)
Recitation: Wednesday, 17:30–18:30, Room 141.A35 (Instructor's Office)

Instructor: Prof. Michail G. Lagoudakis
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Info: www.intelligence.tuc.gr/~lagoudakis

Web Site: www.eclass.tuc.gr/courses/HMMY360/

Textbooks: Sebastian Thrun, Wolfram Burgard, Dieter Fox
Probabilistic Robotics, MIT Press, 2005
Richard S. Sutton and Andrew G. Barto
Reinforcement Learning, 2nd Edition, MIT Press, 2018

Description

An autonomous robot is an entity which continuously interacts with the real world; it perceives, learns, and acts with the purpose of maximizing its own utility. This course covers three key aspects of autonomy: *perception* (how robots process the raw sensor data to extract reliable observations and form a consistent belief about the true state of the world around them), *action* (how robots use their internal belief to make decisions and act in a rational way), and *learning* (how robots use experience through interaction to improve their decision making capabilities over time). The course focuses on modern probabilistic approaches required to handle the uncertainty inherent in the real world.

Participation

The course is open to all graduate students with basic background in mathematics (probability and linear algebra), algorithms (design and analysis), and programming (coding in C/C++, Java, Matlab, Python, or similar languages). Senior undergraduate students may be allowed to register and join the class by permission, only if there is space and they have the required background. Students are encouraged to use the recitation hours for any kind of course consultation (participation, project ideas, ...).

Topics (one week for each topic – total: 13 weeks)

1. Introduction to robotics, review of probability theory
2. Robotic perception and action (sensors and actuators)
3. Recursive state estimation (state and belief space, prediction and correction, Bayes filter)
4. Estimation filters (linear Kalman, extended Kalman, unscented Kalman, histogram, particle)
5. Probabilistic motion models (velocity, odometry)
6. Probabilistic sensor models (beam, scan, feature)
7. Robot localization methods (Markov localization, Gaussian localization)
8. Robot localization methods (Grid localization, Monte-Carlo localization)
9. Robot Mapping (occupancy grid mapping, reflection grid mapping)
10. Simultaneous localization and mapping (SLAM) (EKF-SLAM, GraphSLAM, FastSLAM)
11. Decision making under uncertainty (Markov Decision Processes (MDP), optimal policies)
12. Reinforcement learning (prediction and control, trial and error, approximate representations)
13. Partial observability (Partially Observable MDPs, approximate POMDP solution methods)

Grading

Semester Project (50%), Final Written Examination (50%)

Active class participation will be taken into consideration and a final written examination will ensure sufficient breadth of study. To encourage deeper individual study on at least one topic, each student will have to complete and present a semester project involving application of some method or algorithm covered in class to data from real or simulated robots, such as the Alpha2 and Nao robots of the lab or the robot models of Webots and Gazebo, or to a problem from the own domain of research.