

AE 4803: Robotic Systems and Autonomy

Instructor information:

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Teaching Assistants:

Name: TBD

Email: TBD

Class Location and Time:

TBD

Office Hours:

Instructor office hours: 2:30pm - 3:30pm Monday, Coda Building - 2nd floor

TA office hours: TBD

Class objectives:

The purpose of this course is to provide students with a foundational understanding of methods for planning, control and state estimation in robotics and autonomous systems. The course will cover algorithms for planning, state estimation and filtering, optimal and adaptive control. Applications include intelligent exploration, localization and map building, optimal and robust navigation, multi-robot co-operation, control for autonomous unmanned aerial and mobile robotics and manipulation. Through this course students will learn how to design, analyze and integrate real time software that supports the computational cycles of planning, control and state estimation

Textbooks:

1. *Instructor notes on optimal control and planning algorithms*
2. *Scientific papers in the areas of machine learning, control and robotics. These papers are published in top conferences in Robotics Sciences and Systems(RSS), International Conference on Machine Learning (ICML), Neural Information Processing Systems (NIPS), Inter-*

national Conference on Robotics and Automation (ICRA). Proceedings of these conference are online.

3. Suggested books:

- (a) *Probabilistic Robotics. Sebastian Thrun (Author), Wolfram Burgard(Author), Dieter Fox(Author), Ronald C. Arkin (Editor), MIT press 2006.*
- (b) *Pattern recognition and machine learning. Christopher Bishop(Author) , Springer 2006*
- (c) *Gaussian Processes for Machine Learning. C.E. Rasmussen(Author), C.K.I. Williams (Author). MIT Press 2006*

Website:

All relevant information on the class will be disseminated electronically at Canvas. Each student will be responsible for obtaining notes and homework assignments of the days he/she will miss. No cell-phones, no eating, no reading newspapers, magazines, etc or other material which are not related to the class are allowed.

Homework Guidelines:

There will be 3 homeworks for this course. The homeworks should be written in Latex. All homeworks will include implementation of algorithms on control, planning and learning mainly in Matlab and/or python. **All course assignments will be submitted electronically via Canvas.**

Collaboration:

Some cooperation between teams for solving homework problems can be helpful in learning and, in this respect, is encouraged. This implies that collaboration is acceptable **only** as a means for exchanging ideas, generating thought-provoking discussions and, in general, for obtaining a deeper understanding of the course material. Copying another's team homework solution, however, will not be tolerated.

Grading Policy and Exams:

The grades will be determined based on class participation, homework assignments, two mid-terms, and annual exam according to the rule:

$$\text{Grade} = 50\% \times \text{Homework} + 1 \times 15\% \times \text{Midterm} + 35\% \times \text{Project}$$

Percentage	Grade
90 - 100	A
80 - 89	B
65 - 79	C
50 - 64	D
< 50	F

Tentative Schedule:**1. Optimal Control and Trajectory Optimization.**

- (a) Dynamic Programming Principle
- (b) Linear Quadratic Regulators - Discrete and Continuous Time.
- (c) Differential Dynamic Programming (DDP) - Discrete and Continuous Time
- (d) Pontryagin Maximum Principle (PM) - Discrete and Continuous Time
- (e) Model Predictive Control (MPC) Formulation of DDP and PM

2. Machine Learning (Supervised Learning).

- (a) Probability Theory.
- (b) Least Squares
- (c) Recursive Least Squares
- (d) Gaussian Processes and Inference
- (e) Semi-parametric Gaussian Processes and approximations
- (f) Deep Learning - Feedforward Networks
- (g) Convolutions Neural Networks
- (h) Recurrent Neural Networks

3. Reinforcement Learning.

- (a) Finite Differencing and Stochastic Optimization
- (b) Policy Gradient Theorem
- (c) Policy Gradients with Optimal Baselines
- (d) Natural Policy Gradient
- (e) Cross Entropy and Stochastic Optimization
- (f) Stochastic Search Methods and Stochastic Optimization
- (g) Path Integral Policy Gradients and Information Theoretic Control

4. State Estimation and Sensor Fusion.

- (a) Kalman Filter
- (b) Extended Kalman Filter
- (c) Particle Filters.
- (d) Sensors and observation models -
 - i. Inertia Measurement Unit (IMU).
 - ii. Odometer, Magnetometer.
 - iii. Vision-Perception.
 - iv. Global Position Systems (GPS).
- (e) Sensor Fusion.

Academic and Research Honesty/Integrity Statement

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. Review the Student Code of Conduct and the Academic Honor Code, especially Appendix A: Graduate Addendum to the Academic Honor Code.

Students are expected to perform research in an ethical and responsible manner. All Doctoral and Master's Thesis students are required to take the Responsible Conduct of Research training, and it is expected that students abide by the principles taught in that training while performing research for this thesis course.

Allegations of scientific or scholarly misconduct are handled in accordance with the procedures outlined by the Policy for Responding to Allegations of Scientific or Other Scholarly Misconduct.

Core IMPACTS

Not applicable.

Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services as soon as possible to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.