**Sequential Decision Making in Robotics**
Course ID: CS 599  
Day and Time: Wednesdays 2-5pm  
Location: RTH 406 (the USC catalog is wrong)  
Spring 2011  
Prerequisites for this course are graduate student standing and consent of the instructors. The treatment of the subject will be mathematical, and a solid mathematics background is required.

**Instructors:**

Dr. Geoffrey Hollinger  
Office Hours: By email appointment  
Phone: 904-993-1584  
E-mail: gahollin@usc.edu  
URL: [http://robotics.usc.edu/~geoff](http://robotics.usc.edu/~geoff)

Prof. Gaurav Sukhatme  
Office Hours: By email appointment  
Phone: 213-740-0218  
E-mail: gaurav@usc.edu  
URL: [http://robotics.usc.edu/~gaurav](http://robotics.usc.edu/~gaurav)

**Teaching Assistant/Grader**

None.

**Introduction and Purposes**

This course will examine sequential decision making in robotics with a focus on information gathering, path planning, and related optimization problems. We will discuss both fundamental background material as well as cutting edge research in the following areas: discrete planning, stochastic planning, distributed data fusion, optimization, and algorithms with performance guarantees. The last several lectures will examine specific planning and decision making problems of significant interest to the robotics community, which include active SLAM, manipulation, vehicle navigation, and marine robotics. The discussed techniques will be agnostic to the type of robot used and generalizable across various applications. By the end of this course, students will have mastered the fundamentals of robotic decision making and be conversant in state-of-the-art techniques.

This course will be taught in the style of a research seminar. Students will be expected to analyze the readings and contribute to discussions. In addition to substantial class participation, students will be required to give course presentations, scribe the outcome of discussions, and will be responsible for completing a course research project individually or as a member of a small group.
Course Requirements and Grades

Textbooks: Students are not required to purchase textbooks for this course. All course material will be made available as PDF.

Grading:
40%: Final project
25%: Course presentations
25%: Discussion notes
10%: Active participation in discussions

Students must actively participate in discussion each week. Students will be assigned to present papers in class and scribe discussion notes on a rotating basis. Project proposals are due the 5th week of class. Project mid-term reports are due the 9th week of class. Final project write-ups are due the final week of class. Due to the research seminar nature of this course, assignments will only be accepted after the deadline at the instructors’ discretion.

Course Readings/Class Sessions (not completely firm, but close)

Class will meet for 3 hours once a week. One or more students will be required to present research papers each week, and one or more students will be required to scribe the outcome of the discussion. All students are required to read the assigned readings and participate in discussion. Weekly syllabus is below:

Week 1: Discrete planning overview
a. LaValle, Planning Algorithms (pp. 28-57)
b. Russell and Norvig, AI: A Modern Approach (pp. 71-109)

Week 2: Current methods in discrete planning
a. Koenig and Likhachev, “D*-Lite”
b. Likhachev et al., “Anytime Search in Dynamic Graphs”

Week 3: Stochastic planning overview
a. Thrun, Burgard, and Fox, Probabilistic Robotics (pp. 487-510)
b. Kaelbling et al., “Planning and Acting in Partially Observable Stochastic Domains”
c. LaValle and Kuffner, “Randomized Kinodynamic Planning”
d. Kavraki et al., “Probabilistic roadmaps for path planning in high-dimensional configuration spaces”

Week 4: Current methods in stochastic planning
a. Ferguson and Stentz, “Anytime RRTs”
b. Kurniawati et al., “SARSOP: Efficient point-based POMDP planning by approximating optimally reachable belief spaces”
c. Prentice and Roy, “The Belief Roadmap: Efficient Planning in Belief Space by Factoring the Covariance”
Week 5: Optimization techniques: linear/integer/convex programming
a. Project proposals due
b. Boyd and Vandenberghe, Convex Optimization (pp. 67-90)
c. Papadimitriou and Steiglitz, Combinatorial Optimization (pp. 342-382 and pp. 433-454)

Week 6: Planning with performance guarantees overview
a. Vazirani, Approximation Algorithms (pp. 1-37 and pp. 93-117)
b. Blum et al., “Approximation Algorithms for Orienteering and Discounted-Reward TSP”
c. Krause and Guestrin, “Near-optimal Observation Selection Using Submodular Functions”

Week 7: Performance guarantees in robotics (part 1)
b. Singh et al., “Efficient Informative Sensing using Multiple Robots”
c. Hollinger et al., “Efficient Multi-Robot Search for a Moving Target”

Week 8: Performance guarantees in robotics (part 2)
a. Gerkey and Mataric, “A formal analysis and taxonomy of task allocation in multi-robot systems”

Week 9: Data fusion for multi-robot systems
a. Project update reports due
b. Makarenko and Durrant-Whyte, “Decentralized Data Fusion and Control in Active Sensor Networks”
c. Grocholsky, Information-Theoretic Control of Multiple Sensor Platforms (pp. 68-119)

Week 10: Special topic: Active Simultaneous Localization and Mapping
a. Sim and Roy, "Global A-Optimal Robot Exploration in SLAM”
b. Leung et al., “Active SLAM for structured environments”

Week 11: Special topic: Planning for manipulation

Week 12: Special topic: Learning and planning for vehicle navigation

Week 13: Special topic: Decision making for marine robotics
a. Final project write-up due
b. Smith et al., "Planning and Implementing Trajectories for Autonomous Underwater Vehicles to Track Evolving Ocean Processes based on Predictions from a Regional Ocean Model"
Bibliography


Statement for Students with Disabilities

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

Statement on Academic Integrity

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one’s own academic work from misuse by others as well as to avoid using another’s work as one’s own. All students are expected to understand and abide by these principles. Scampus, the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A: http://www.usc.edu/dept/publications/SCAMPUS/gov/. Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: http://www.usc.edu/student-affairs/SJACS/.