CS 4803/8803
Robot Intelligence: Planning in Action
TR 1:35-2:55, Boggs 228
Fall 2008

Instructor: Mike Stilman mstilman@cc.gatech.edu
Office hours: TSRB 240 Thursday 12:00 - 1:00 or by appointment.

Summary:
We discuss algorithms for robots and other complex systems that make intelligent decisions in high dimensional or continuous spaces of options. Intelligent decisions take into account both present and future constraints on the system. The course will cover methods for planning with symbolic, numerical, geometric and physical constraints. Topics will range from classical and stochastic planning to continuous robot domains and hybrid control of dynamic systems.

Requirements:
The course will consist of three group programming projects. Each group will also design and implement a final project on a research-level planning topic through discussion with the instructor. The initial projects will cover each subarea of planning and be graded on algorithm implementation and analysis results as follows:

Classical Planning	(20%)
Motion Planning	(20%)
Dynamic/Stochastic Planning	(20%)

The final project will make up (40%) of the grade and will be of a similar nature to research for a conference publication. Possibilities for the final project include:

- Robot arm planning and control.
- Planning with abstractions.
- Planning for a novel balancing platform.
- Grasp planning for a robot hand.
- Planning or control projects relevant to ongoing research.

Tentative Schedule:

Aug. 19 – 21	Classical Planning Predicate Logic, STRIPS, Frame Problem, Causal-link planning
Aug. 26 – 28	Planning Methods Plan Graph Search, Planning as Satisfiability, Constraint Satisfaction
Sept. 2 – 4	Extensions of Classical Planning Heuristics, Hierarchical Task Networks, Resource Scheduling

Sept. 9 – 11	Grid Based Planning Search Tools, Dijkstra, Dynamic Environments, Plan Refinement
Sept. 16 – 18	Motion Planning for Navigation Cell Decompositions, Trajectory Generation, Potential Fields
Sept. 23 - 30	Math Tools for Motion Review of Kinematics, Collision Detection, Sampling Strategies, Hierarchical Decompositions
Oct. 2 – 14	Planning for Robot Arms Configuration Space, Sampling Based Methods, Probabilistic Roadmaps Random Trees, Sampling Strategies
Oct. 16 – 21	Kinodynamic Planning Planning with Primitives, Planning with controllers
Oct. 23 – 30	Planning With Uncertainty Adaptive Planning, Markov Decision Processes, HMMs
Nov. 4 – 11	Dynamic Domains More MDPs, Controllers, Attractors, Learning Dynamics
Nov. 13 – 25	Further Topics in Planning Manipulation, Assembly, Navigation Among Movable Obstacles
Dec. 2 – 4	Final Project Presentations

Prerequisites:
The course has no official prerequisites. We will assume some familiarity with programming, algirthm design, complexity and statistics. However, we will also provide the necessary references for students to gain this familiarity in limited scope as required for understanding course material.

Books (Recommended):
"Artificial Intelligence: A Modern Approach," Russel, Norvig
"Reinforcement Learning" Sutton, Barto
"Principles of Robot Motion", Howie Choset et. al
"Planning Algorithms", Steve LaValle
"Robot Motion Planning", Jean-Claude Latombe

Articles will be posted in accordance with topics (Some examples):
"The FF Planning System: Fast Plan Generation Through Heuristic Search," J. Hoffmann, B. Nebel. Journal of AI Research, vol 14, pp. 253-302, 2001

"Fast planning through planning graph analysis," Avrim Blum and Merrick Furst.

Artificial Intelligence, 90:281--300, 1997.

"The Findspace Problem" Gerald J. Sussman, MIT Tech Report 1973

"Automatic Synthesis of Fine-Motion Strategies for Robots", Lozano-Perez, T., Mason, M. T. and Taylor, R. H., International Journal of Robotics Research, Vol. 3, No. 1, 1984, pp.3--24. Also MIT AI Memo 759, December 1983.

Course Websites:

"Planning and Decision Making", S. LaValle: http://msl.cs.uiuc.edu/~lavalle/cs497/
"Robot Motion Planning," S. Akella: http://www.cs.rpi.edu/~sakella/rmp01/
"Artificial Intelligence Planning" Blythe, Ambite and Gil:
http://www.isi.edu/~blythe/cs541/