CMSC 828L - Spring 2006

(Expected to be also approved by Aerospace, Mechanical, and Electrical Engrg Depts)

Robot Motion Planning

Prerequisites: One of (MATH 240, MATH 461, MATH 341) or equivalent, and one of (CMSC 132, CMSC 214) or equivalent, or experience working with Matlab/Mathematica.

Description: Recent years have seen a steady increase in the use of techniques for automatic planning of robot motion in a complex environment. Affected areas include robot systems for space, agriculture, and medicine; new research in computational geometry, CAD-CAM and VLSI design, protein folding analysis in biology, computer vision research. Applications vary widely, from tele-operation of planetary rovers and undersea probes to painting/welding/assembly manipulators, surgical robots, hospital delivery robots, and animation and virtual reality software. We see more emphasis on motion planning in an unstructured environment, where the robot has to take its workspace as is, rather than deal with a predesigned scene (as, e.g. on an automotive assembly line). Approaches used range from simple common sense heuristics to complex computational algorithms with assured convergence, and draw on tools from computational geometry and topology. Coupled with the algorithmic machinery are issues of control, kinematics and dynamics, sensing media, and cognitive science (such as human operators' spatial reasoning). In this course, a unified view on the mathematical, algorithmic, and implementation issues of the motion planning problem will be given, and major approaches to its solution reviewed, with the emphasis on dealing with uncertainty of the unstructured environment.

Topics to be covered:

- Basic models of robot motion planning.
- Motion planning with complete information: Piano Movers model; configuration space; connectivity graphs; computational complexity of algorithms.
- Motion planning with uncertainty: operating in an unstructured/unknown environment; algorithm convergence; topological issues.
- The curse of dimensionality: two-dimensional versus three-dimensional motion planning; highly redundant systems.
- Sensing and motion planning: the role of sensing media (tactile, proximity, vision) in the algorithm structure and efficiency.
- Effect of system geometry, kinematics, and dynamics on planning strategies.

Assignments: 6-8 homeworks. A semester-long individual course project.
Exams: Midterm – individual project review/report. Final – project presentation/report.
Grading: Homework – 50%. Project: midterm review – 20%; final – 30%.
Sources: Book - V. Lumelsky, *Sensing, Intelligence, Motion*, Wiley Publ., 2005;
Lecture notes; research papers.
Time, place: Fridays 10 - 12:30pm, CSI 3120
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