Leon H. Charney School of Marine Sciences
UNIVERSITY OF HAIFA

Autonomy and Motion Planning Course- 229.9066

Dr. Oren Gal

Course Overview:

The purpose of this course is to present a coherent framework for solving motion planning problems, as well as several existing methods to solve specific problems. This presentation will use the concepts of configuration space and related spaces (state, control, motion, and information spaces) to formulate problems. It will use algorithms based on random sampling and cell decomposition to explore the connectivity of these spaces. The course content will be illustrated with examples drawn from areas such as mechanical design, manufacturing, graphic animation, medical surgery, and biology. It will emphasize methods that are efficient, robust, and relatively easy to implement, over methods that strive for optimal worst-case performance. It will emphasize methods with provable guarantees of performance over purely heuristic methods that are often effective only in some specific examples. Most of the methods presented will involve various forms of geometric computing (e.g., interference detection between objects, distance computation, space partitioning, shape matching, etc).

Syllabus:

#1 - Course Overview

- What is motion planning?
- Basic problem and variants
- Applications

#2 - Configuration space and basic techniques

- Notion of a robot configuration
- Representations
- Structure of configuration space

#3 - Configuration space and basic techniques

- Notion of a path, trajectory
- Obstacle mapping
- Basic path-planning methods: roadmaps, cell decomposition, potential fields

#4 - Collision detection and distance computation

- Role of collision detection and distance computation in motion planning
- Feature-tracking approach
- Hierarchical bounding approach

#5 - Probabilistic roadmaps -- Basic Techniques

- Principle and rationale of probabilistic roadmaps
- Convergence of PRM planners

#6 - Probabilistic roadmaps -- Sampling Strategies

- Multi-query vs. single-query sampling
- Multi-stage sampling
- Obstacle-sensitive sampling

#7 - Probabilistic roadmaps -- Sampling Strategies

- Narrow-passage sampling
- Diffusion strategies
- Delayed collision checking
- Visibility-based connection

#8 - Coordination of multiple robots

- Configuration X time space
- Moving obstacles
- Centralized vs. decoupled planning

#9 - Coordination of multiple robots

- Velocity tuning
- Coordination diagram

#10 - Nonholonomic robots

- Notion of a nonholonomic robot
- Basic maneuvers for a car-like robot
- Reed and Shepp curves
- Lie brackets
- Sampling-based planner

#11 - Kinodynamic planning and optimal planning

- Equation of motion and dynamic constraints
- State space
- Two-phase planning
- Sampling-based planning

#12 – Students seminar lectures

#13 - Students seminar lectures

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Grading Policy:

30% - presence, 70% seminar lectures and analysis of a paper.

Previous demands:

The students are expected to have basic knowledge and interest in geometry and algorithms, and to have the skills to complete a significant programming assignment.

Course Text:

1. J.C. Latombe. *Robot Motion Planning*, Kluwer Academic Pub., Boston (MA), 1991.
2. Planning Algorithms by *Steve LaValle* (UIUC).