6.S078 Planning Algorithms, Fall 2013

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Instructor

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Organization

The course will be divided into three (roughly) equal parts, each focusing on one type of planning problem: robot motion planning, symbolic action planning and decision-theoretic planning. We will also highlight interactions between these types of planning problems as we go. Most of the examples will be drawn from robotics, but the applications to other areas, such as computer games, will be discussed.

The philosophy of the class is to learn by implementing. Thus, the assignments will involve implementation of the various algorithms we discuss. Any support code will be provided in Python, but if you prefer another language, that's fine (but there won't be support code).

- The course has 6.006 as a pre-requisite. In particular, I will assume that you understand graph search algorithms well and the notion of orders of growth in algorithms.
- There is a textbook: *Planning Algorithms* by Steven M. LaValle. The full text is available on-line at `http://planning.cs.uiuc.edu`; this is linked from the Stellar site. You can buy a hardcopy from Amazon if you prefer. We will supplement the text with additional readings when appropriate.
- The book *Artificial Intelligence: A Modern Approach* by Russell and Norvig is a useful reference for the second and third part of the course.
- Grading will be based on homework (programming) assignments (40%) and 3 in-class quizzes (60%). The quizzes are tentatively scheduled for October 2, November 6 and December 4.
- There is a Stellar web site `http://stellar.mit.edu/S/course/6/fa13/6.S078/` where handouts will be posted. This will also be used for you to upload problem solutions.
- Anything that you hand in must be your own work – handing in work from your fellow students or from Web sources is **never** allowed. You are free to discuss approaches to homework with other students but you what you hand in must be your own work.

Assignment 1 (due Wed. Sept 11 before class)

Implement a simple motion planner for a robot (modeled as a list of convex polygons) that can translate (not rotate) in the plane. One of the vertices of the polygon (e.g. the first vertex of the first polygon) should be designated as a reference point; positions of the polygon correspond to positions of that vertex. There will be a list of fixed obstacles, modeled as a list of convex polygons. The shape of the polygon and the obstacles will be user provided, do not make assumptions about them. The user will provide a start and goal position.

Assume a grid at some fixed resolution (user provided) and that the robot's position is confined to the grid intersections. The robot is constrained to move along the "lines" in the grid (horizontally and vertically). A valid solution is a list of positions corresponding to grid intersections, starting with the indicated start position and ending with the indicated goal position. The robot must not collide with any of the obstacles for any position on the path; note that there must not be collisions while moving between the grid points. Your test for collision should be "exact" (up to floating point accuracy).

You will need to implement a general graph search routine that can do (a) depth-first, (b) breadth-first, (c) shortest-path (uniform-cost), (d) A^* search (using a user-provided heuristic function).

You should provide a capability for displaying the paths of the robot. There is a simple Python class (borrowed from 6.01), posted on Stellar, that allows you to create a window and draw on it. If you prefer to used some other display mechanism, that's fine, but no need to get carried away.

You should uplaad a zip file with your code to the Stellar site. Also write a brief description of your approach in a PDF file and include some runs of your algorithm, with tables that show the length of the paths and the running time as you change the robot and the environment. Include images of the paths in some representative environments. Experiment with all the graph-search methods, including two heuristic functions for A^* (one admissible and one not admissible but which leads to faster running time). You will be expected to demo your code in class.

Possible (optional) extensions: include some rotations; assume the obstacles are moving with fixed, known, velocities; assume the robot has some movable parts and can change its shape; try bi-directional search. Or, suggest something else.