Albert-Ludwigs-Universität Freiburg
Lecture: Introduction to Mobile Robotics
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Sheet 12

Topic: Path Planning and Recapitulation

Submission deadline: July 25, 2012
Submit to: `mobilerobotics@informatik.uni-freiburg.de`

Exercise 1: Dijkstra's algorithm

Dijkstra's algorithm computes shortest path trees in graphs for a single start or goal node. If the cells of a grid map are represented as vertices of a graph with edges between the neighboring cells, the algorithm can be used for robot path planning. For this exercise, we define consider the 8-neighborhood of a cell $\langle x, y \rangle$, which is defined as the set of cells that are adjacent to $\langle x, y \rangle$ either horizontally, vertically or diagonally.

1. Let $M(x, y)$ denote an occupancy grid map. Formulate a function for the edge costs between two cells that allows for planning of collision-free shortest paths on the grid map using Dijkstra's algorithm.
2. Implement the algorithm in octave using the given stub file and test it with the given map file in *dijkstra_framework.zip*. Visualize the planned path on the map for start $\langle x, y \rangle = \langle 23, 34 \rangle$ and goal $\langle x, y \rangle = \langle 41, 16 \rangle$, and submit the resulting image along with your code. See the code stub for additional hints.

Exercise 2: A^* algorithm

The A^* algorithm computes the shortest path from a start to a goal node. It employs a heuristic to perform an "informed" search with higher efficiency than Dijkstra's.

1. Formulate an edge cost function as in 1.1, and define an appropriate A^* heuristic for path planning.
2. Implement and test the algorithm as in 1.2.
3. How many cells have been expanded by each algorithm during the search? What is the computational complexity of the algorithms (O-notation)?
4. In which situations can the two different algorithms return different paths?

Exercise 3: Map convolution

Convolution, e.g., gaussian blurring, of the occupancy grid map can be used to achieve short paths with increased distance to obstacles. Implement a function for this purpose, and integrate it into your A^* implementation. Submit a third image for the resulting path with the convolution.

Exercise 4: Rao-Blackwellization

Explain the idea of Rao-Blackwellization in general. How is the principle utilized for landmark-based SLAM, how for grid-based SLAM and where does the performance gain come from in both cases?

Exercise 5: Bayes Rule and Bayes Filter

- What is calculated in a Bayes Filter?
- What are the underlying assumptions?
- Can you derive the equation of the Bayes Filter and name the assumptions which are used?
- Which assumptions are critical and which are not?

Exercise 6: Probabilistic Motion Model

- Name two types of motion models that are often found in practical applications
- Explain the two models using a small drawing for each.
- What are the differences between them?
- Which problem arises in the velocity based motion model and how to overcome it?