A PRM Approach to Handle Huge Numbers of Path Planning Queries in Different Configuration Spaces

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A probabilistic roadmap (PRM) planner incrementally computes an approximate representation of a robot's free space until either it finds a solution path, or it exceeds a timeout condition. It combines two basic operations: milestone sampling and milestone connection. The former generates the roadmap nodes: it picks a configuration according to some probability measure and tests if it is collision-free. The latter generates a roadmap edge: it picks a pair of milestones and tests if a simple path between them is collision-free.

With appropriate strategies this approach can process reasonably well small numbers of planning queries. But it raises challenging issues when tens of thousands of queries, or more, in different configuration spaces have to be processed in order to solve a single, bigger motion planning problem. Typically, such a problem occurs when the motion to plan involves changing contacts (like in legged locomotion on irregular terrain and in dexterous manipulation) or when there is uncertainty in the geometry and location of the obstacles. Then two limitations of the PRM planner are its inherent inability to determine whether a single planning query in one given configuration space is feasible, or not, and the fact that it wastes much time in testing for collision many milestones and connections, most of which will not end up in any solution path.

To address this challenge, this talk will propose to break the operations performed by the PRM planner into smaller ones, e.g., partially testing a sampled configuration or a connection for collision. In this way, at any one time, a roadmap will be made up of milestones and connections most of which have not been fully tested. This approach will give the planner more choices at each step: test further if a milestone or a connection is collision-free, sample and test partially a new configuration, or test partially a new connection. Hence, hopefully better PRM strategies can be developed aimed at finding a solution path more quickly, when one exists, or at estimating sooner that no solution path exists. The talk will discuss the application of this approach to motion planning problems with uncertainty and/or changing contacts.

Note: This talk is based on prior discussion of the author with Tim Bretl, Kris Hauser, and David Hsu.