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The University of Illinois, Urbana-Champaign's Parasol Lab researches task and motion planning. During my summer at Parasol, I learned that the classic motion planning problem is how to compute a path for a robot to travel from a start to a goal location while avoiding known obstacles. However, motion planning includes a much larger body of research problems ranging from planning the motion of virtual objects in gaming, to planning assembly in manufacturing settings, to planning surgeries.

In order to simulate and run motion planners, Parasol researchers have built the Parasol Motion Planning Library (PMPL), a large C++ code base that provides a variety of motion planning tools that all Parasol researchers benefit from and add to. However, over the decade-plus that researchers have added to the library, the code has been refactored multiple times to provide additional functionality, such as the ability to group multiple robots together. Therefore, some of the code is not compatible with the latest version of PMPL.

Parasol is far from the only research group working on motion planning, and much of PMPL provides unique or optimal functionality. Therefore, Parasol is currently working on making PMPL open source so that anyone can use the work of Parasol researchers to motion plan. However, the code base must be cleaned to provide guarantees on documentation, functionality, and testing before it can be a truly useful tool for the public.

During my time at Parasol, I worked on preparing code that implements a Bridge Test Sampler to be added to the version of PMPL that will be made open source. I expanded the code to add the ability to work with more than one robot, cleaned up the interface to better match other Samplers in PMPL, and wrote a tester that can periodically be run to make sure the Sampler continues to function properly.

Samplers are a vital part of PMPL. Motion planning quickly becomes computationally complex, so computing every possible path a robot might travel is impractical in most cases. Instead, motion planners have had success with sampling-based planners such as the Probabilistic Roadmap (PRM) which randomly samples a set of configurations where the robot might exist, and then attempts to find traversable paths between this limited number of sampled configurations.

However, these sampling-based techniques can be dramatically more or less successful based on which Sampler is used, or, in other words, how the configurations are selected. Some environments contain narrow paths between obstacles. It is probabilistically unlikely that a sampler will choose a point in one of these narrow passages, and so it may be more difficult for the algorithm to find a path through one of these narrow paths. Therefore, Samplers that have a higher chance of finding points in narrow passages are desirable.

The Bridge Test Sampler is one attempt to solve this Narrow Passage Problem. It is relatively computationally cheap to select a point, but computationally expensive to check if there is a collision-free path between two points. Therefore, the Bridge Test effectively acts as a filter that only retains sampled points if they exist in a narrow passage. In practice, it tests two points at some set distance from the sampled point, in opposite directions, and discards the sampled point if the ends of this 'bridge' aren't within obstacles.

After successfully cleaning the Bridge Test Sampler for the open-source project, I moved on to implementing a newer sampler, the Dynamic Regions PRM (DR-PRM), which guides the sampling of configurations in narrow passages by moving along topological skeletons which describe the connectivity of the space. Parasol researchers had great success implementing DR-PRM for individual robots, so I worked with pre-existing code to expand functionality for multiple robots.

However, this remains an open question. While DR-PRM works extremely well with individual robots in certain settings, we found that even adding a single additional robot deteriorates the functionality of the algorithm. We believe this is because DR-PRM is very efficient in constructing paths that robots might travel. This saves time, as it is not testing as many possible paths for collisions, but in the case of multiple robots, it may be a victim of its own success. If there are fewer paths, bottlenecks, where multiple robots attempt to travel at the same time, are more likely. Further research is needed to balance DR-PRM's efficiency with the need for parallel paths in which multiple robots may travel at once.

References

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