A Framework for Guided Motion Planning

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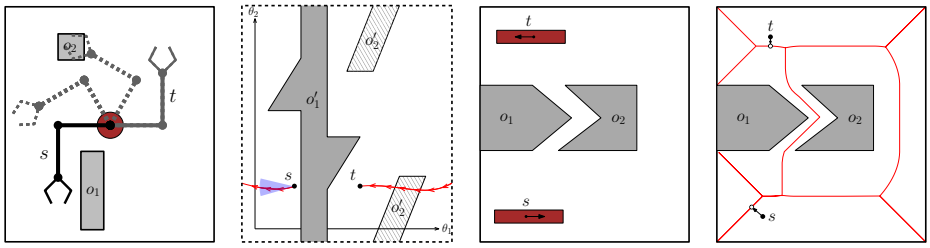
Most variants of randomized sampling based algorithms bias their sampling using various heuristics related to the known underlying structure of the search space. In this work [1], we formalize the intuitive notion of *guided search* by defining the concept of a *guiding space*. We propose that this vague notion of "known underlying structure" can be described with respect to a distribution from which motion planning problems are sampled. Given such a distribution, we propose a generic tree-based search algorithm composed of two stages. First, offline samples from this distribution are used to create a mapping from a given problem to a guiding space. Then, given a new motion planning instance, the guided search algorithm uses this mapping to determine which nodes on a search tree should be chosen for expansion. One valid interpretation is that solutions to tasks in the guiding space (which are easier to solve) provide heuristic estimates for the difficulty of tasks in their pre-image. We show multiple benefits of our framework. First, we demonstrate that our framework encapsulates many seemingly distinct prior methods, thus providing a more succinct language in which to discuss them. In doing so it suggests simplified implementations of known algorithms which are more conducive to direct comparison. Namely we show that the guidance of different algorithms can be directly compared and suggest an information theoretic method for doing so, which experimentally matches intuition when tested on known algorithms in a variety of environments. Finally, not only can this metric be used to train deep models for performing guided search (out-performing traditional models that predict cost-to-go [2]) but it also suggests improvements to existing methods, and facilitates hybrid algorithms that combine guidance from multiple sources.



(a) (b) (c) (d)

Fig. 1: The Lazy and MedialAxis guiding spaces, see full paper for more detail [1]

References

1. Amnon Attali, Stav Ashur, Isaac Burton Love, Courtney McBeth, James Motes, Marco Morales, and Nancy M Amato. A framework for guided motion planning. *arXiv preprint*, 2024.
2. Sherry Li, Amnon Attali, Marco Morales, and Nancy M Amato. Learning node expansion likelihoods via sampling efficiency in tree-based motion planning. *arXiv preprint*, 2024.