Research Review

Anytime Dynamic A*: An Anytime, Replanning Algorithm

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Abstract:

This research review is based on popular research paper "**Anytime Dynamic A*: An Anytime, Replanning Algorithm**" by Maxim Likhachev, Dave Ferguson, Geoff Gordon, Anthony Stentz and Sebastian Thrun.

This paper presents a graph-based planning and replanning algorithm which is able to produce bounded suboptimal solutions in an anytime fashion. The algorithm tunes the quality of its solution based on available search time, at every step reusing previous search efforts. When updated information regarding the underlying graph is received, the algorithm incrementally repairs its previous solution. The result is an approach that combines the benefits of anytime and incremental planners to provide efficient solutions to complex, dynamic search problems. The paper presents theoretical analysis of the algorithm, experimental results on a simulated robot kinematic arm, and two current applications in dynamic path planning for outdoor mobile robots.

Introduction:

Planning for systems operating in the real world involves dealing with a number of challenges not faced in many simpler domains. Firstly, the real world is an inherently uncertain and dynamic place; accurate models for planning are difficult to obtain and quickly become out of date. Secondly, when operating in the real world, time for deliberation is usually very limited; agents need to make decisions and act upon these decisions quickly.

To cope with imperfect information and dynamic environments, efficient replanning algorithms have been developed that correct previous solutions based on updated information. These algorithms maintain optimal solutions for a fraction of the computation required to generate such solutions from scratch.

However, when the planning problem is complex, it may not be possible to obtain optimal solutions within the deliberation time available to an agent. **Anytime algorithms have shown themselves to be particularly appropriate in such settings, as they usually provide an initial, possibly highly-suboptimal solution very quickly, and then concentrate on improving this solution until the time available for planning runs out**.

Replanning algorithms have concentrated on finding a single solution with a fixed sub-optimality bound, and anytime algorithms have concentrated on static environments. But the most interesting problems, for us at least, are those that are both dynamic (requiring replanning) and complex (requiring any-time approaches).

This paper presents a heuristic-based, anytime replanning algorithm that bridges the gap between these two areas of research. Anytime Dynamic A* (AD*), continually improves its solution while deliberation time allows, and corrects its solution when updated information is received.

Anytime Dynamic A*:

There are efficient algorithms for coping with dynamic environments and complex planning problems. However, what if when we are facing both complex planning problem and dynamic environment at the same time.

Anytime Dynamic A* algorithm combines D* Lite and ARA* into a single anytime, incremental replanning algorithm. AD* performs the series of searches using decreasing inflation factors to generate a series of solutions with improved bounds, as with ARA*. When there are changes in the environment affecting the cost of edges in the graph, locally affected states are placed on the OPEN queue with priority equal to the minimum of their previous key value and their new key value, as with D* Lite. States on the queue are then processed until the current solution is guaranteed to be suboptimal.

Conclusion:

This paper presents Anytime Dynamic A*, a heuristic based, anytime replanning algorithm able to efficiently generate solutions to complex, dynamic path planning problems. The algorithm works by continually decreasing a sub optimality bounds on the solution, reusing previous search efforts as much as possible. When changes in the environment are encountered, it is able to repair its pervious solution incrementally.

References:

- M. Likhachev et al. "Anytime Dynamic A*: An Anytime Replanning Algorithm" ICAPS pp. 262-271 2005.
- Stuart Russell and Peter Norvig – Artificial intelligence, a modern approach [3rd edition].