Sampling and Robustness in Multi-Robot Visibility-Based Pursuit-Evasion

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Abstract

Sampling and Robustness in Multi-Robot Visibility-Based Pursuit-Evasion Given a two-dimensional polygonal space, the multi-robot visibility-based pursuit-evasion problem tasks several pursuer robots with the goal of establishing visibility with an arbitrarily fast evader. The best-known complete algorithm for this problem takes time doubly exponential in the number of robots. However, sampling-based techniques have shown promise in generating feasible solutions in these scenarios.

Existing sampling-based algorithms have long execution times and high failure rates for complex environments. We first address that limitation by proposing a new algorithm that takes an environment as its input and returns a joint motion strategy which ensures that the evader is captured by one of the pursuers. Starting with a single pursuer, we sequentially construct data structures called Sample-Generated Pursuit-Evasion Graphs to create such a joint motion strategy. This sequential graph structure ensures that our algorithm will always terminate with a solution, regardless of the complexity of the environment.

Another aspect of this problem that has yet to be explored concerns how to ensure that the robots can recover from catastrophic failures which leave one or more robots unexpectedly incapable of continuing to contribute to the pursuit of the evader. To address this issue, we propose an algorithm that can rapidly recover from catastrophic failures. When such failures occur, a replanning occurs, leveraging both the information retained from the previous iteration and the partial progress of the search completed before the failure to generate a new motion strategy for the reduced team of pursuers.

The final contribution is a novel formulation of the pursuit-evasion problem that modifies the pursuers' objective by requiring that the evader still be detected, even in spite of the malfunction of any single pursuer robot. This novel constraint, whereby two pursuers are required to detect an evader, has the benefit of providing redundancy to the search, should any member of the team become unresponsive, suffer temporary sensor disruption/failure, or otherwise become incapacitated. The proposed formulation produces plans that are inherently tolerant of some level of disturbance.

For each contribution discussed above, we describe an implementation of the algorithm and provide quantitative results that show substantial improvement over existing results.

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