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Improved discretization for a modified mixed trajectory pursuit-evasion game

Authors: Zacharias Komodromos (PhD Candidate in Electrical Engineering), Kyle Williams (Sandia, Org), Dr. Todd Humphreys (UT, Dept of Aerospace)

Introduction / Motivation

Previous work has examined a pursuit-evasion game with a target for the attacker, where trajectories are evaluated on a cost function for each entity. The players seek a Nash equilibrium set of controls or a risk-dominance equilibria when one does not exist.

The current enumeration process for the trajectories generates uniformly radial paths as acceleration control inputs. This method includes trajectories in the computation that might be obviously unfavorable to take, fruitlessly increasing the burden since the number of trajectories the players evaluate dictates how computationally intensive finding the equilibria is.

Reducing the number of trajectories or increasing the potential of the ones being evaluated will allow for less burdensome processing or an improvement in game outcomes. Thus, an improved discretization method for the mixed trajectory game would be beneficial.

Approach

One possible approach is to prune the trajectories before they are used to obtain a Nash equilibrium set of controls by comparing each trajectory cost to some baseline and discarding any below this baseline. One such baseline would be a Proportional Navigation (PN) based solution, used in homing devices. Since costs greater than the PN cost are discarded before solving for Nash equilibrium controls, only lower cost trajectories are considered, with the option of falling back on the PN solution if all options are discarded. This will ensure that, at minimum, we match a PN solution, and ideally outperform it while reducing the original computational burden.

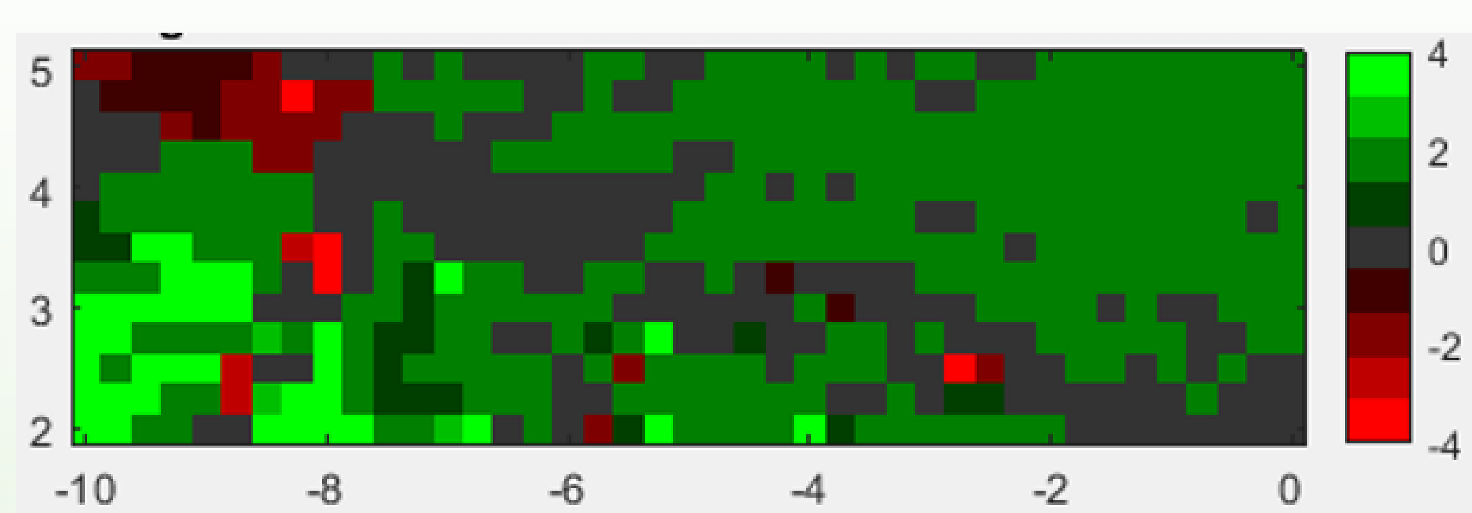
Another possible approach is to change the trajectories evaluated by dynamically generating them based on the current state of the game. Instead of enumerating in all directions, the enumeration could be based on some pattern around a known good solution, such as the PN solution. Patterns around the PN solution can then be tested to find lower cost options that may deviate from the baseline. Some pattern following the uniform radial trajectories could be used but discarding trajectories in directions where the entity clearly should not be considering.

The two approaches are not mutually exclusive. A version of dynamically generating the trajectories based on the PN solution, and then also pruning any that are higher cost than the PN, could further diminish the computational demand.

Current Status / Results

The current testing platform allows for a pursuer with varying initial position and an evader attacking a target, both with fixed positions. The pursuer initial position is iterated through a defined area and a game is established, each time saving the result. The iteration process is run twice, once with a NashGame algorithm and once with a PN based algorithm. In this manner, each time a new pattern needs to be tested for the second approach, a comparison can be made with another pattern's performance against an exclusively PN based approach.

An example of some of the results are shown below. The boxed area represents the initial position of the pursuer, an evader starts 2m below the left corner and the target is fixed 2m below the right corner. The color pattern explains how well the NashGame algorithm pursuer performed compared to the PN algorithm pursuer starting at the position in the figure. By changing the number of trajectories or the way they are chosen, one can compare the results of the change with a previous run.



Challenges

A major challenge is collecting the results for each pattern. Depending on the pattern and the level of complexity in the trajectory as well as the discretization of the initial position of the pursuer, the simulations can take a significant amount of time even while being parallelized.

Another challenge is determining how to choose what patterns to test. While intuition might suggest to cluster around the PN solution, initial results show that the number of favorable outcomes compared to the exclusive PN solution increases while the general success rate is reduced.

Next Steps / Future Work

The next steps for the project include implementing the pruning process discussed in the approach section and finding a more streamlined and insightful way of choosing patters to test.

The first will help with improving the success rate of the NashGame algorithm against the PN algorithm. The second will likely improve the pace of the project and result in a more effective and robust solution which will hopefully also improve the general success rate of the NashGame algorithm.

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