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Applied Statistics and Computational Modeling
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Project Title

Cooperative search strategies for pursuing adversarial evaders

Project Objective

The project's primary objective is to develop estimators of optimal cooperative search strategies and demonstrate the ability to locate an evasive adversary using simulation experiments.

Project Description

Pursuit-evasion is a multi-agent sequential decision problem wherein a group of coordinating agents, called the pursuers, seeks to locate an intelligent adversary, called the evader, as efficiently as possible. The pursuers are allowed to adapt their search behavior in real-time using accruing information which may come from mobile sensors, informants, or projections based on models of adversary behavior. Similarly, the evader can adapt their behavior in real-time to information they receive. Pursuit-evasion problems arise in a wide range of contexts including artificial intelligence, wildlife management, border security, law enforcement, and defense.

The pursuit-evasion problem is naturally formulated in the language of game theory. Thus, one dominant approach to estimating an optimal strategy for the pursuers is to postulate a mathematical model for the system dynamics and subsequently solve for an equilibrium. However, for this approach to be tractable, substantial simplifications are required. In this project, we address the challenges of solving pursuit and evasion and present a method for estimating the optimal pursuer strategy that relaxes these assumptions. Our proposed method is a novel

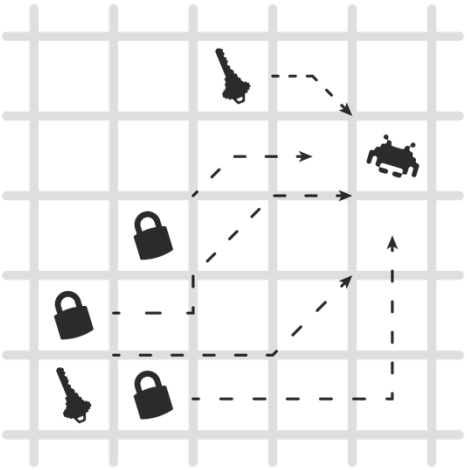
variant of a reinforcement learning algorithm called Thompson sampling. We demonstrate the performance through a series of simulation experiments.

Project Relevance to Nuclear Nonproliferation

Pursuit and evasion is an integral problem in nuclear nonproliferation. A primary application is the rapid location of illicit nuclear material. Reducing time to capture of an evasive adversary can save lives and prevent damage. Efficient mathematical models for pursuit and evasion problems can help inform experts in real-time decisions.

Products and Outcomes of Project

We developed a novel variant of Thompson sampling, a reinforcement learning algorithm, to estimate the optimal pursuer strategy. This method utilizes cooperation among pursuers to decrease time to capture. To demonstrate the performance, we implemented the method as a C++ library that is designed to be configurable. A user can customize the environment, evader strategy, pursuer strategy, etc. to fit their specific problem.



Publications and Reports

NICHOLAS MEYER, ERIC LABER, NICHOLAS KAPUR, ROBERT BRIGANTIC, "Cooperative Search Strategies for Pursuing Adversarial Evaders". In preparation.

NICHOLAS MEYER, "Estimating optimal strategies for large scale spatio-temporal sequential decision problems". North Carolina State University Electronic Thesis Database, 2017.

Presentations

NICHOLAS MEYER, ERIC LABER, NICHOLAS KAPUR, ROBERT BRIGANTIC, "Cooperative Search Strategies for Pursuing Adversarial Evaders," University and Technical Interchange 2016, Raleigh, North Carolina, June 7-9, 2016.

NICHOLAS MEYER, ERIC LABER, NICHOLAS KAPUR, ROBERT BRIGANTIC, "Cooperative Search Strategies for Pursuing Adversarial Evaders," University Program Review 2017, Walnut Creek, California, June 6-8, 2017.