A Survey of Advancements in Green Security Games

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Abstract

The field of Green Security Games (GSG) has proven useful in the protection of wildlife. By modelling attackers and defenders as intelligent agents in a repeated simulation we can employ a winning algorithm to deploy scarce resources in actual green security scenarios. This paper summarizes the concept of GSGs, surveys the advancements that have been made, and suggests future opportunities for research.

1 Introduction

The domain of green security entails the struggle between poachers/illegal fishers and rangers charged to protect the wildlife. The rangers are limited in number and have strict constraints applied.

In the field of Artificial Intelligence, Stackelberg Security Games (SSG) have been used to predict potential attacker moves in order to assist in defender strategies. The application of this strategy to green security domains is called Green Security Games (GSG, introduced by [1]). The game abstracts the reality of poachers versus rangers patrolling a vast wildlife area into a grid-based simulation between attackers and defenders, both of which are AI agents. The attacker's goal is to place snares for wildlife without being caught, while the defender's goal is to detect both the snare and the attacker. Furthermore, the attacker behaves human-like and does not always behave optimally.

The game is run in episodes [1]. By simulating multiple rounds of this game, an optimized defender strategy is formed. This strategy is applicable to assist real-world rangers in deciding where and how patrols should be deployed.

Advancements in this field introduce additional constraints, challenge assumptions, and propose novel methods for improving defender strategy. Qian et al. [2] show that the environment must be partially-observable to model the defender's decision to explore new areas or patrol areas known to have snares. Wang et al. [3] introduce the idea that both attackers and defenders have access to real-time information that can be used to evade and track. Finally Gholami et al. [4] show that a defender strategy that combines a machine-learning agent with an online learning algorithm that does not rely on prior information can outperform existing models.

2 Methods/Theory

2.1 Green Security Games (GSG)

The Green Security Game as introduced by Fang et al. [1] is a zero-sum game. It is run in T ($< \infty$) rounds, and each round has multiple episodes. The defender has K guards to protect N ($\geq K$) targets, each with a different reward. A guard (defender) can defend one target and an attacker can attack one target. If the attacker attacks an unguarded target, the defender is penalized and the attacker is rewarded. If the attacker attacks a defended target, the attacker is penalized and the defender is rewarded. After each round the defender assigns guards in order to maximize the expected utility.

2.2 Exploration/Exploitation Tradeoffs

Explain what Qian et al. [2] show as a shortcoming of GSG [1].

Restless Multi-armed Bandit (RMAB) Problem

Whittle Index Policy Algorithm

2.3 Real-Time Information

Explain what Want et al. [3] show as shortcomings of prior work, and how GSG-I augments the existing game and DeDOL helps to solve it.

GSG-I Problem

DeDOL Algorithm

2.4 Imperfect Prior Knowledge

Explain what Gholami et al. [4] show as shortcomings of prior work, and how MINION-sm and MINION help improve defender strategies in GSGs.

MINION-sm

MINION

3 Discussions

Include: * GSG abstraction - benefits and trade-offs. What benefit does the GSG abstraction have over an attempted perfect simulation? * RMAB - How does this improve on the GSG abstraction? Are there any assumptions being made? * GSG-I - Same question * MINION - Is this seemingly the ultimate solution? How would it perform against GSG-I? How can its work be combined with previous work discussed in this paper?

4 Conclusions

- Summarize research
- Discuss how PAWS is helping law enforcement currently, and how these algorithms can be used to improve it
- Find a unique idea as a future research goal

5 References

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