Cops and Thieves

AASMA Project Proposal

Group 32

ABSTRACT

This project addresses the need for improved cooperative multi-agent learning environments through the design and implementation of an innovative, thematic game, "Cops and Thieves". Building upon the principles of the traditional predator-prey model, our approach introduces enriched complexity, dynamic elements, and a scoring system to augment the learning opportunities for artificial intelligence systems.

In the "Cops and Thieves" game, agents, represented as cops and thieves, have unique objectives and action sets. Thieves aim to gather items scattered across a world environment while evading the pursuing cops. The cops, on the other hand, aim to apprehend the thieves before they can collect all items. This scenario introduces a balance of competitive and cooperative dynamics, as agents must not only outperform the opposing team but also coordinate effectively with their teammates.

Through this novel game design, we expect to contribute to the multi-agent reinforcement learning (MARL) field by providing a more intricate, dynamic, and engaging environment for training intelligent agents. We anticipate that this work will lead to more robust learning algorithms capable of handling complex, cooperative, and competitive scenarios with varying objectives and constraints. Ultimately, the results could have far-reaching implications for real-world applications, from autonomous vehicles to collaborative robotics.

KEYWORDS

AASMA; Multi-Agent Reinforcement Learning; Artificial Intelligence; Dynamic Game Design

1 INTRODUCTION

In the realm of artificial intelligence, the development of multi-agent systems capable of intelligent cooperation and competition is of paramount importance. These systems have potential applications in numerous fields, including autonomous vehicles, robotics, and network security, where intelligent agents must interact and make decisions in complex environments. This project proposes a unique, engaging, and challenging multi-agent game environment, "Cops and Thieves", designed to advance the training and evaluation of such systems.

Motivation for this project arises from the limitations of existing multi-agent environments. Traditional games, such as the predator-prey model, often present a binary win-loss outcome and lack the environmental complexity and dynamic elements necessary to fully explore the capabilities of multi-agent systems. Therefore, an enriched environment that caters to a more extensive range of strategic interactions is needed to foster the development of more advanced and robust multi-agent learning algorithms.

Related work in the field includes the development of various multi-agent learning environments, such as OpenAI's "hide and seek", which provides agents with diverse roles and objectives, or Google's "Football", where agents need to coordinate to score goals. However, these environments often focus on a single type of interaction (cooperation or competition) and may not fully explore the balance of these dynamics as proposed in "Cops and Thieves".

The problem we address is the lack of a comprehensive, dynamic, and challenging environment for training multi-agent reinforcement learning (MARL) systems. This project is relevant as advancements in MARL have significant implications for many fields where intelligent agents operate in shared environments.

The objective of this project is to design and implement the "Cops and Thieves" game following some suggested enhancements. We aim to create an environment that requires agents to not only compete against each other but also cooperate within their teams, all while navigating and adapting to a dynamic, complex game environment.

2 OUR APPROACH

"Cops and Thieves" is a cooperative-competitive multi-agent system where agents, segregated into two factions - cops (predators) and thieves (prey), operate within a dynamic grid environment. Each team has distinct objectives and available actions. Cops aim to capture the thieves by moving to the same cell, leading to the thief's disappearance from the game. Thieves strive to gather all items scattered across the grid before being apprehended. The system architecture consists of a central game controller, which maintains the state of the game environment and enforces the game rules, and multiple agent instances, each equipped with a decision-making module and a communication module for information exchange with team members.

The game environment is characterized by a grid layout wherein agents can move freely, barring the presence of fixed block cells, which serve as immovable obstacles, and movable block cells, which thieves can strategically relocate to obstruct cops' pathways. These block types, along with collectible objects, can be either randomly scattered or pre-determinedly positioned on the grid, adding an element of randomness and noise to the testing environment, thereby enhancing its realism and dynamism for multi-agent systems. Thieves can only perceive these objects upon occupying the same cell and are aware of cops' presence only in adjacent cells. Similarly, cops can detect thieves only in adjacent cells. This limited visibility encourages strategic gameplay and the development of advanced learning algorithms capable of handling diverse objectives and strategies.

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Written in Python, this simulation's design emphasizes the balance of competition and cooperation in multi-agent systems, addressing the need for environments where agents must simultaneously collaborate and compete. By allowing communication between like agents and including diverse actions and objectives, the system architecture encourages the development of cooperative strategies, presenting an environment challenging enough for training advanced multi-agent reinforcement learning algorithms.

In conclusion, the design choices for the "Cops and Thieves" game aim to combat oversimplification in multi-agent environments. By offering a complex, dynamic, and challenging environment, we anticipate the game will stimulate advancements in the training and capabilities of multi-agent systems, thereby making significant strides in the field.

3 EVALUATION

To validate the objectives of the "Cops and Thieves" game project, we propose an empirical evaluation involving both quantitative and qualitative assessments. The success of the game as a learning environment will be gauged based on the performance and behaviour of the agents as they interact within the game.

Performance Metrics:

1. Capture Efficiency: The average number of turns taken by the cops to apprehend the thieves. A lower number indicates that the cops are learning effective strategies for catching the thieves.

2. Collection Efficiency: The average number of items collected by the thieves before being apprehended. Higher numbers suggest that the thieves are becoming more adept at navigating the environment and evading the cops.

3. Win-Loss Ratio: The ratio of games won by the cops to games won by the thieves. A balanced ratio indicates a well-designed, challenging game environment.

4. Cooperation Score: A metric that assesses the degree of cooperation within a team, such as the frequency of communication or the coordination of actions. Higher scores suggest that agents are learning to work together effectively.

Qualitative Assessment:

1. Strategy Complexity: An analysis of the complexity of the strategies adopted by the agents. Are they simply reacting to the immediate game state, or are they planning several moves ahead? Are they adapting their strategies based on the actions of other agents?

2. Adaptability: An evaluation of how well the agents adapt to events in the game. Are they able to adjust their strategies when a teammate gets captured? Are they able to adjust when a teammate captures another agent?

3. Robustness: An assessment of how consistently the agents perform across different game configurations, such as different map layouts or different initial positions of agents and items.

These metrics and assessments will provide a comprehensive evaluation of the "Cops and Thieves" game as a multi-agent learning environment. They will help validate whether the game is effectively promoting the development of advanced, robust multi-agent reinforcement learning algorithms and facilitating complex, dynamic interactions between agents.

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