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Unlocking Autonomous Telescopes through Reinforcement Learning: An Offline Framework and Insights from a Case Study

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Optimizing observational astronomy campaigns is becoming a complex and expensive task for next-generation telescopes, where manual planning of observations may tend to reach suboptimal results in terms of optimization.
Reinforcement Learning (RL) has been well-demonstrated as a valuable approach for training autonomous systems, and it may provide the basis for self-driving telescopes capable of scanning the sky and optimizing the scheduling for astronomy campaigns.
We have developed a framework for the optimization of telescope scheduling using RL techniques, based on a dataset containing data on a discrete set of sky locations that the telescope should visit, and a reward metric.
We compared several RL algorithms applied to an offline simulation dataset based at the Stone Edge Observatory, considering a discrete set of sky locations to visit and using "t-effective"as a reward metric, a measure of the quality of the data.
Deep Q-Networks (DQNs), belonging to the class of value-based methods, have shown remarkable success in the optimization of astronomical observations in our dataset. In the full environment, the average reward value in each state was found to be 92%±5% of the maximum possible reward, while on the test set it resulted in 87%±9% of the maximum possible reward.

Brainstorming idea [title]

Exploring Techniques for Achieving Collaboration among Self-Driving Telescopes: A Brainstorming Idea

Brainstorming idea [abstract]

Collaboration tasks may benefit the world behind self-driving telescopes, bringing to the development of a coordinated group of telescopes spread around the world, with the idea of achieving a common goal: discovering the unknown. Several branches related to machine learning can be used to achieve this goal, such as game theory, reinforcement learning, and deep learning architectures taking into consideration interactions among agents and temporal dependencies such as Recurrent Neural Networks.
Among these, Multi-agent RL (MARL) techniques enable different agents to coordinate their actions and share information efficiently. This application could be used to train autonomous telescopes with the goal of maximizing the amount and quality of data gathered while minimizing redundancy. For example, a re-engineering of the reward function and the introduction of a more complex framework could be used to penalize the reward, which may embed information about the quality of the data, if data coming from a location has been already gathered from other autonomous entities.
A cluster of telescopes serving as watchers of the skies could distribute the intelligence and push forward the boundaries of the problem.

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