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Autonomous Fabry-Perot cavity locking via deep reinforcement learning

This work explores the application of Reinforcement Learning (RL) to the control of a Fabry-Perot (FP) optical cavity, a key component in interferometric gravitational-wave detectors. By leveraging RL's inherent ability to handle high-dimensional non-linear systems, the project aims to achieve robust and autonomous cavity locking—a process typically hindered by elevated finesse values, mirror velocity, and non-linear dynamics.
A custom simulator reproducing the cavity's electric field dynamics serves as the basis of a Gymnasium environment, where an RL agent is trained to acquire lock under realistic conditions. This training is optimized by rewarding effective control actions, and the environment includes strategies to mitigate the SimToReal gap by addressing latency and noise sources—thereby reducing discrepancies between simulated and physical systems. Beyond simulation, an experimental setup is proposed to verify and refine the training process.
Ultimately, the goal is to integrate simulation insights and experimental validation to enable a seamless transition of the trained RL agent from a virtual platform to real-world cavity locking. Future work will focus on enhancing control reliability and efficiency for more complex optical systems.

AI keywords

reinforcement learning, simulation to reality gap, real-time inference

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