北京大学
Peking University

报告地点：新奥工学大楼2047
时间: 07月16日 15:30 - 17:00

COOL RESEARCH

系列报告第二十三讲

报告人：Enrique Mallada (约翰霍普金斯大学副教授)

报告题目：Nonparametric Analysis and Control of Dynamical Systems: Stability, Safety and Policy Improvement

Control, Optimization, Operations research, and Learning（COOL）Research Seminar是由北京大学先进制造与机器人学院学院相关领域的几位老师发起，旨在为国内外青年学者提供一个交流平台，分享和探讨最新最有趣的研究成果，促进领域内和跨领域沟通学习，推动前沿理论的发展。

北京大学 PEKING UNIVERSITY | COLEEGE. OF ENGINEERING 工学院

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Nonparametric Analysis and Control of Dynamical Systems: Stability, Safety and Policy Improvement

Abstract: This talk presents a novel nonparametric framework for analyzing dynamical systems and synthesizing control policies that relies purely on trajectory data and is designed to exploit GPU parallelization for scalability. The key insight behind this work is to relax strict objectives, such as invariance and optimality, and replace them with weaker conditions that enable a flexible trade-off between accuracy, computational complexity, and sample efficiency. First, we introduce the concept of recurrence, a relaxation of invariance that allows trajectories to leave a set temporarily before returning within a finite time. This relaxed condition serves as a functional substitute for invariance and provides an alternative foundation for analyzing dynamical systems. By leveraging recurrence, we develop integral Lyapunov and barrier function conditions, where function values are required to be eventually monotonic over a finite time window rather than strictly increasing or decreasing. This relaxation offers a more flexible framework for stability and safety verification, enabling a trade-off between verification accuracy and computational complexity. Next, we turn to the policy optimization problem and introduce a class of nonparametric policies designed for continuous action spaces. These policies rely purely on (expert) trajectory data to construct a nonparametric lower bound, Q_{lb}, on the optimal action-value function Q^\star. Crucially, we show that this policy representation admits a policy improvement theorem, overcoming a key limitation faced by function approximation methods in continuous action spaces. Building on this result, we develop a practical algorithm that drives continual policy improvement by selectively incorporating new expert demonstrations, ensuring efficient data use while achieving monotonic performance gains.

Speaker: Enrique Mallada (约翰霍普金斯大学副教授)

Biography: Enrique Mallada has been an Associate Professor of Electrical and Computer Engineering at Johns Hopkins University since 2022. Before joining Hopkins in 2016, he was a Post-Doctoral Fellow in the Center for the Mathematics of Information at Caltech from 2014 to 2016. He received his BSc in Telecommunications from Universidad ORT, Uruguay, in 2005 and his Ph.D. in Electrical and Computer Engineering with a minor in Applied Mathematics from Cornell University in 2014. Dr. Mallada has received the Johns Hopkins Alumni Association Teaching Award in 2021, the NSF CAREER award in 2018, the Center for the Mathematics of Information (CMI) Fellowship from Caltech in 2014, and the Cornell ECE Director's Ph.D. Thesis Research Award in 2014. His research interests lie in control and dynamical systems, machine learning, and optimization, with applications to safety-critical networks and systems, particularly power grids.

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