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Neural Lyapunov Control with Stability Guarantees

Learning for control of dynamical systems with formal guarantees remains a challenging task. In this talk, we introduce a learning framework to simultaneously stabilize an unknown nonlinear system with a neural controller and learn a neural Lyapunov function to certify a region of attraction for the closed-loop system. The algorithmic structure consists of two neural networks and a satisfiability modulo theories (SMT) solver. The first neural network is responsible for learning the unknown dynamics. The second neural network aims to identify a valid Lyapunov function and a provably stabilizing nonlinear controller. The SMT solver then verifies that the candidate Lyapunov function indeed satisfies the Lyapunov conditions. We provide theoretical guarantees of the proposed learning framework in terms of the closed-loop stability for the unknown nonlinear system. We illustrate the effectiveness of the approach with a set of numerical experiments. The talk is based on a recent paper published in NeurIPS 2022 (joint work with Ruikun Zhou, Thanin Quartz, and Hans De Sterck).