Model-Free Online Optimal Adaptive Control and Non-Zero Sum Games with Applications to Network Security

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Abstract

Optimal feedback control design has been responsible for much of the successful performance of engineered systems in aerospace, industrial processes, vehicles, ships, and robotics. Traditional optimal feedback control design is performed *offline* by solving optimal design equations including the algebraic Riccati equation (ARE), the Game ARE for linear systems and Hamilton-Jacobi equations for nonlinear systems. Techniques from reinforcement learning are used to design a new family of *adaptive controllers* based on actor-critic mechanisms that converge *online*, in real time to optimal control and game theoretic solutions by using data measured along the system trajectories. I will present novel forms of *online* optimal control and multi-player games in a communication graph where each agent is allowed to interact only with its neighbors. Sociobiological groups such as flocks, swarms, and herds have built-in mechanisms for cooperative control wherein each individual is influenced only by its nearest neighbors, yet the group achieves optimal synchronization behaviors. Novel policy iteration and adaptive learning algorithms are proposed to guarantee optimal performance while the agents synchronize to the leader node. I will also introduce model-free optimal adaptive control algorithms for networked control systems that are being attacked by persistent adversaries. Appropriate approximators, such as neural networks with local-information tuning laws are used to provide online solutions to the highly coupled partial differential equations arising from coupled Hamilton-Jacobi equations. The proposed approach combine optimal control, neuro-inspired adaptive control, game theory, reinforcement learning, cooperative control and serve as a tool for approaching difficult optimal control and game theory problems that without bio-inspired approaches are impossible to solve.