New Reinforcement Learning Structures for Real-Time Optimal Control and Differential Graphical Games: Applications to HRI and Industrial Process Control

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Abstract: This talk will discuss some new feedback control structures for learning online the solutions to optimal control problems and multi-player differential games. A new family of distributed multi-agent games on communication graphs is presented. Techniques from reinforcement learning are used to design a new family of adaptive controllers based on actor-critic mechanisms that converge in real time to optimal control and game theoretic solutions. Continuous-time systems are considered. Application of reinforcement learning to continuous-time (CT) systems has been hampered because the system Hamiltonian contains the full system dynamics. Using our technique known as Integral Reinforcement Learning (IRL), we develop reinforcement learning methods that do not require knowledge of the system dynamics. In the linear quadratic (LQ) case, the new IRL adaptive control algorithms learn the solution to the Riccati equation by adaptation along the system motion trajectories. In the case of nonlinear systems with general performance measures, the algorithms learn the (approximate smooth local) solutions of HJ or HJI equations. New algorithms will be presented for solving online the non zero-sum and zero-sum multi-player games. A new Experience Replay technique is given that uses past data for present learning and significantly speeds up convergence. New methods of Off-policy Learning allow learning of optimal solutions without knowing any dynamic information. New RL methods in Optimal Tracking allow solution of the Output Regulator Equations for heterogeneous multi-agent systems. Applications are made to Human-Robot Interaction and to efficient control of an Industrial Mineral Grinding Flotation Process.