

Preface

Background of this Book

Optimal control theory is a mathematical optimization method for deriving control policies as well as guaranteeing the stability. Optimal control generally solves problems of nonlinear dynamical systems, which are ubiquitous in nature. Being studied in science and engineering for several decades, the optimal control can be derived by many methods. Discovered by Richard Bellman, dynamic programming equation is a necessary condition for optimality associated with the mathematical optimization method known as dynamic programming. However, it is often computationally untenable to break the “curse of dimensionality” as known in running the dynamic programming. Approximation solution for dynamic programming is required and the adaptive dynamic programming (ADP) method was first proposed by Werbos in 1977. In this method, a system, called “critic,” is built to approximate the performance index function in dynamic programming to obtain the approximate optimal control solution of Hamilton–Jacobi–Bellman (HJB) equation. Specifically, by using a function approximation structure, which is generally constructed by neural networks to approximate the solution of HJB equation, the method obtains the approximate optimal control policy offline or online. Having gained much attention from researchers for decades, ADP algorithms make deep foundation and much progress.

The Content of this Book

This book focuses on the most recent developments in iterative adaptive dynamic programming algorithms. The book is organized in ten chapters: First, Chap. 1 presents basic principles of ADP algorithms. In Chap. 2, a finite horizon iterative ADP algorithm is proposed to solve the optimal control problem for a class of discrete-time nonlinear systems with unfixed initial state. Chaps. 3–5 focus on Q -learning algorithms which are developed to solve the optimal control problems

and infinite horizon optimal tracking problems. In Chaps. 6 and 7, ADP algorithms are developed for discrete-time nonlinear systems with general multiobjective performance index functions. In Chap. 8, an online ADP-based optimal control scheme is developed for continuous-time chaotic systems and in Chap. 9, an off-policy integral reinforcement learning algorithm to obtain the optimal tracking control of unknown chaotic systems is estimated. The final chapter proposes a novel sensor scheduling scheme based on ADP, which makes the sensor energy consumption and tracking error optimal over the system operational horizon for wireless sensor networks with solar energy harvesting.

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Adaptive Dynamic Programming Approach

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