# Optimal Control Using Adaptive Dynamic Programming: Fundamental Theory and New Development

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## ABSTRACT

It is known that dynamic programming is a powerful tool in solving the optimal control problems based on the principle of optimality. However, it is often computationally untenable to run true dynamic programming due to the backward numerical process required for its solutions, i.e., the well-known "curse of dimensionality". In order to overcome this difficulty, adaptive dynamic programming (ADP) is proposed as a promising method, the idea of which is to approximate the optimal solutions successively via iterative algorithms implemented by the neural networks. In this report, we will present some fundamental optimal control theory and recent development of ADP algorithms, which includes as follows: 1) A novel method named off-policy is proposed to solve the model-free problems, which only requires system data with different control inputs rather than the accurate system mathematical models. 2) Given an initial cost function which is not necessarily optimal, the sequences of cost function and control policy are updated through the neural networks based on HJB equation. 3) The iterative sequences of cost function and control policy are rigorously proved to converge to the optimal ones. 4) Considering the unavoidability of time delays, we further study the infinite-horizon and finite-horizon optimal control problem for the nonlinear systems with time delays. Some numerical simulation examples are provided to demonstrate the feasibility and effectiveness of these theories and designs.

**Biography:**



Huaguang Zhang received the Ph.D. degree from Southeast University, Nanjing, China, in 1991. From 1992 to 1994, he did his postdoctoral research at Northeastern University, Shenyang, China. He has been with Northeastern University since 1991, and is currently as a Full Professor and Ph.D. advisor. He has authored and coauthored over 300 journal and conference papers, four monographs and co-invented more than 50 patents. He has been severing as an associate Editor of Automatica since 2008, an associate Editor of IEEE Transactions on neural networks since 2010, an associate Editor of IEEE Transactions on Cybernetics since 2007, an associate editor of Neurocomputing since 2007. In addition, he is a fellow

of IEEE, the E-letter Chair of IEEE CIS Society, the former Chair of the Adaptive Dynamic Programming & Reinforcement Learning Technical Committee on IEEE Computational Intelligence Society. Besides those he has been a member of the Neural Systems and Applications (NSA) Committee of IEEE Circuits and Systems Society, a member of the Blind Signal Processing (BSP) Committee of IEEE Circuits and Systems Society, a member of the Technical Committee on Computational Intelligence of the Systems, Man, and Cybernetics Society since 2007. He was awarded the Outstanding Youth Science Foundation Award from the National Natural Science Foundation Committee of China in 2003. He was named the Cheung Kong Scholar by the Education Ministry of China in 2005. He is a recipient of the IEEE Transactions on Neural Networks Outstanding Paper Award (2012). His current research interests include Adaptive Dynamic Programming, Fuzzy System Theory, Fuzzy Control, Neural Network-Based Control, Adaptive Control, Chaotic Control, Complex Industry Process Automation, Electric Power System Automation, Motor Driving System Automation.