

Using AI and Machine Learning Tools to Solve Optimal Control Problems

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Abstract:

Machine learning is one of the most important branches of artificial intelligence. Researchers have been using AI and Machine Learning techniques in modern control theory. Self-learning control methodologies are a good representative of such efforts. Reinforcement learning (RL) recently has become a major force in the machine learning fields. On the other hand, adaptive dynamic programming (ADP) has now become popular in control communities. Both RL and ADP have roots in dynamic programming and in many ways they are equivalent. Major breakthroughs of ADPRL for optimal control were achieved around 2006, when iterative ADP approaches were introduced. The optimal control of nonlinear systems requires to solve the nonlinear Bellman equation instead of the Riccati equation as in the linear case. The discrete-time Bellman equation is more difficult to work with than the Riccati equation because it involves solving nonlinear partial difference equations. Though dynamic programming has been a useful computational technique in solving optimal control problems, it is often computationally untenable to run it to obtain the optimal solution, due to the backward numerical process required for its solutions, i.e., the well-known "curse of dimensionality". Self-learning optimal control based on ADPRL provides efficient tools for tackling the following two problems. (1) Nonlinear Bellman equation is solved using iterative ADP approaches which are shown to converge. (2) Neural networks are employed for function approximation in order to obtain forward numerical process. Samples of the vast amount of new developments since five years ago in ADPRL for optimal control will be introduced in this lecture.

Bios:

Derong Liu received the Ph.D. degree in electrical engineering from the University of Notre Dame in 1994. He was a Staff Fellow with General Motors Research and Development Center, from 1993 to 1995. He was an Assistant Professor with the Department of Electrical and Computer Engineering, Stevens Institute of Technology, from 1995 to 1999. He joined the University of Illinois at Chicago in 1999, and became a Full Professor of Electrical and Computer Engineering and of Computer Science in 2006. He was selected for the "100 Talents Program" by the Chinese Academy of Sciences in 2008, and he served as the Associate Director of The State Key Laboratory of Management and Control for Complex Systems at the Institute of Automation, from 2010 to 2015. He is now a Full Professor with the School of Automation, Guangdong University of Technology. He has published 19 books. He is the Editor-in-Chief of Artificial Intelligence Review (Springer). He was the Editor-in-Chief of the IEEE Transactions on Neural Networks and Learning Systems from 2010 to 2015. He received the Faculty Early Career Development Award from the National Science Foundation in 1999, the University Scholar Award from University of Illinois from 2006 to 2009, the Overseas Outstanding Young Scholar Award from the National Natural Science Foundation of China in 2008, and the Outstanding Achievement Award from Asia Pacific Neural Network Assembly in 2014. He is a Fellow of the IEEE, a Fellow of the International Neural Network Society, and a Fellow of the International Association of Pattern Recognition.