

Lecture 1.

Robust Learning with Approximate Dynamic Programming and Kernel Methods

Decision making is ubiquitous in science and engineering. Reinforcement Learning (RL) and Approximate Dynamic programming (ADP) algorithms provide a structured approach to tackle the different decision making challenges. Due to the problem of the “curse of dimensionality”, finding the exact strategy or policy might be challenging. Several methods, such as linear approximate dynamic programming (LADP), have emerged as an alternative to solving dynamic programming (DP) problems. The promising results obtained using those methods make DP more appealing to solve decision making problems for complex systems. Nevertheless, even state-of-the-art DP algorithms are not efficient in terms of computing time. Consequently, most of the algorithms require off-line calculations. In practical applications the system usually changes dynamically; new states might become part of the system and some actions that were not accounted for before might become available. Therefore, a policy that was optimal previously might not be optimal anymore or might even lead to disastrous results. I present a new class of dynamic programming algorithms that combine supervised and unsupervised learning to mitigate the “curse of dimensionality”. Machine-Learning and kernel methods techniques are used to cluster similar states and reduce the dimensionality of the problem. We also consider uncertainties within the transition probability matrices and the cost function and use robust optimization formulations to mitigate the effect of uncertainty within the transition probability matrices. An example of option pricing is discussed. I also discuss how to solve RL problems in an on-line framework using the algorithms presented by considering an example of a city evacuation plan.

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Biography: Theodore B. Trafalis, PhD, is a Professor at the School of Industrial and Systems Engineering at the University of Oklahoma, USA and adjunct professor in the School of meteorology. In 2014 was on a sabbatical visiting the school of Electrical and Computer Engineering, National Technical University of Athens, Greece. He earned his BS in mathematics from the University of Athens, Greece, his MS in Applied Mathematics, MSIE, and PhD in Operations Research from Purdue University. He is a member of INFORMS, SIAM, International Society of Multiple Criteria Decision Making, and the International Society of Neural Networks. He has been listed in several Who's Who biographies such as in the 1993/1994 edition of Who's Who in the World. He was a visiting Assistant Professor at Purdue University (1989-1990), an invited Research Fellow at Delft University of Technology, Netherlands (1996), a visiting Associate Professor at Blaise Pascal University, France, and at the Technical University of Crete (1998). He was also an invited visiting Associate Professor at Akita Prefectural University, Japan (2001). The academic year 2006-2007 was on a sabbatical at the National Center for Scientific Research "Demokritos", Institute of Informatics and Telecommunications, Computational Intelligence Laboratory (CIL), Athens, Greece. In June 2011 was invited researcher at the Institute of Applied Mathematics, University of Toulouse, France. In March 2014 he was invited professor at the Department of Computing, Unitec, Auckland, New Zealand. In 2015 he was also visiting professor in LATNA, Higher School of Economics, Nizhniy Novgorod, Russia. His research interests include: operations research/management science, mathematical programming, interior point methods, multiobjective optimization, control theory, artificial neural networks, kernel methods, evolutionary programming data mining, global optimization and weather applications. He has published more than one hundred fifty articles in journals, conference proceedings, edited books, made over one hundred technical presentations, and received several awards for his papers. In 2004 he received the Regents Award at the University of Oklahoma for his research activities. He has been funded through National Science Foundation (NSF), NOAA, Office of the Army and received the NSF Research Initiation Award in 1991. In 2006 he was the editor of a special issue in Support Vector Machines for the journal of Computational Management Science. He also co-edited a special issue in "Learning from Data" for the same journal. He has coauthored a research monograph with Springer under the title "Robust Data Mining" that was published in 2013. Prof. Trafalis currently serves as the chief editor of *Intelligent Control and Automation* and an associate editor for the *Journal of Heuristics* and several

other journals. In addition he has been on the Program Committee of several international conferences in the field of intelligent systems, data mining and optimization. He was also co-organizer of the *International Conference on the Dynamics of Disasters*, Athens, Greece, 2006 and organizer of the 1st, 2nd, 3rd and 4th International Conference in Industrial Systems and Design Engineering that were held in Athens, Greece, June 2013, 2014, 2015 and 2016 respectively.