STOCHASTIC CONTROL AND COMMUNICATION

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PRE-REQUISITES : Comfort with probability.

INTENDED AUDIENCE : Students, researchers and practitioners of control and automation across any discipline.

INDUSTRY SUPPORT : Industries working in control and automation, decentralized multiagent systems.

COURSE OUTLINE :

The legacy of control is marked by a historic misconception that stochastic control problems could be solved using deterministic controllers superimposed with optimal state estimators and conventional communication protocols. Over time, we realized that this architecture is suboptimal and co-design of communication and control offers orders of magnitude of improvements.

This applies to systems such as smart cities, transportation systems, power grids, gaming and financial markets. This complex subject requires simultaneous application of control theory and communication theory. At present these elements are taught separately in courses designed either exclusively for deterministic control theory, or exclusively for communication theory. This leaves behind a gap, namely blending insights from both disciplines to arrive at approaches for networked control problems. This course seeks to fill this gap.

It will begin with centralized stochastic control, and then highlight open issues that arise in decentralization and the role of communication theory. Finally it will cover communication theory and establish viewpoints from which stochastic control and communication theory can be approached simultaneously.

ABOUT INSTRUCTOR :

Prof. Ankur is an Associate Professor with the Systems and Control Engineering group at Indian Institute of Technology Bombay (IITB). He received his B.Tech. from IITB in 2006, M.S. in 2008 and Ph.D. in 2010, both from the University of Illinois at Urbana-Champaign (UIUC). From 2010-2012 he was a post-doctoral researcher at the Coordinated Science Laboratory at UIUC. His research interests include information theory, the role of information in stochastic control, game theory, combinatorial coding theory problems, optimization and variational inequalities, and operations research. He is an Associate (from 20152018) of the Indian Academy of Sciences, Bangalore, a recipient of the INSPIRE Faculty Award of the Department of Science and Technology, Government of India, 2013, Best paper awards at the National Conference on Communications, 2017, Indian Control Conference, 2018, International Conference on Signal Processing and Communications (SPCOM) 2018, Excellence in Teaching Award 2018 at IITB and the William A. Chittenden Award, 2008 at UIUC. He was a consultant to the Securities and Exchange Board of India on regulation of high frequency trading. He has been a visiting faculty at MIT, USA, University of Cambridge, UK, NUS, Singapore and IISc Bangalore.

COURSE PLAN :

Week 1: Markov decision process, finite horizon problem formulation, examples, principle of optimality, Bellman equation
Week 2: Infinite horizon problems, Optimality criteria (average cost, discounted cost), Bellman equation, optimality of Markov policies
Week 3: Computing optimal policies, linear programming formulation
Week 4: Partially observed Markov decision processes, reduction to the information state
Week 5: LQR problem, Kalman filter
Week 6: LQG problem, separation principle, optimality of linear policies
Week 7: Witsenhausen counterexample. information structure,
Week 8: Intrinsic model of stochastic control, LQG static teams, optimality of linear policies
Week 9: Variants of the Witsenhausen problem, Bansal Basar problem, optimizer's approach
Week 10: Communication and decentralized control. Canonical communication problems of source coding, channel coding and rate distortion theory
Week 11: Shannon's coding theorems
Week 12: Shannon's coding theorems and optimizer's approach