Naman Aggarwal

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RESEARCH INTERESTS

Learning Theory, Optimal Control, Stochastic and Networked Control, Game Theory, Multi-agent Systems

EDUCATION

Indian Institute of Technology Bombay

Interdisciplinary Dual Degree *2016-2021*

B.Tech, Aerospace Engineering

M.Tech, Systems and Control Engineering

GPA: 9.09/10 (overall)

PUBLICATIONS

Naman Aggarwal, Ankur A. Kulkarni, Jayakrishnan Nair, "A Scalarized VCG Mechanism for Supply-side Markets", *to be submitted*, *IEEE Transactions on Automatic Control* [2]

RESEARCH PROJECTS

- **Information Structures for Stochastic Control Problems | Master's Thesis** *Ongoing*
  Advisor: Prof. Ankur Kulkarni *Systems and Control Engineering, IIT Bombay*
  Introduction: We investigate the role of information in stochastic dynamic decision problems. Informational constraints can be interpreted as means of facilitating privacy to different agents participating in the dynamic decision problem and acutely affect the nature of the optimal controller as demonstrated by Witsenhausen. Control action of any agent in such problems serves a dual role - that of controlling the system in the usual sense, and of implicit communication of private information of an agent (or timestep) to the following agent (or timestep).
  - We formulate the communication of private information explicitly by allowing noisy channels between agents and study the effect of this information leakage on the decision problem objective.
  - Currently exploring ε-DP (differentially private) mechanisms like the Laplace mechanism as solution concepts to define the conditional probability distribution of the noisy channel.
- **Mechanism Design for Supply-side Markets | Bachelor's Thesis** *Jan 2020 - July 2020*
  Advisors: Prof. Ankur Kulkarni & Prof. Jayakrishnan Nair *SC, IIT Bombay & EE, IIT Bombay*
  Introduction: We study a supply allocation problem for a set of suppliers wherein each supplier has its own *private* cost model. The goal is to design a mechanism that induces efficient allocations at Nash equilibria i.e. Nash equilibrium supply allocations minimize the aggregate cost of all suppliers. While such a mechanism design is trivially possible if one were to bid entire cost functions (as in the classical VCG mechanism), can efficient supply allocations be realized at Nash equilibrium using just scalar signals is the question we answer in our work.
  - Designed a mechanism that accepts scalar bids from suppliers and constructs surrogate cost functions to determine their supply allocations through an allocation rule and payoffs through a pricing rule.
  - Proved that Nash equilibria of the resulting non-cooperative game result in efficient supply allocations.
  - Characterized the two-sided market problem (consumers and suppliers participate simultaneously) and proposed an iterative procedure to converge at the optimal production level for the given set of consumers and producers.
  - Designed a penalty payment scheme to operate the two-sided market in a 'fair' manner and disincentivize the 'mischievous' supplier from supplying the entire demand at Nash equilibrium.

[1] All project reports available on website

[2] Visit https://namanaggarwal.github.io/files/journal_draft.pdf if the hyperlink doesn't work

- **Survey on Distributed Sensor-Controller Networks | Bachelor's Thesis** *Aug 2019 - Dec 2019*
  Advisors: Prof. Ankur Kulkarni & Prof. Jayakrishnan Nair *SC, IIT Bombay & EE, IIT Bombay*
  Introduction: We conduct a survey of problems involving the control of LQ systems where the sensor and the controller are physically separated. The data packets are transmitted over a network and the packet drops are modelled as i.i.d. Bernoulli processes. Information sets at the sensor and the controller are characterized by the underlying communication protocol – TCP-like (w acknowledgement) or UDP-like (w/o acknowledgement).
  - Derived the optimal controller corresponding to the TCP-like communication protocol. Showed that the separation principle holds and the optimal controller is a simple linear feedback control based on the state estimate.
  - Derived the optimal estimator for the UDP-like protocol. Showed that the error covariance matrix depends on the control action hence the separation principle doesn't hold since estimation and control are coupled.
  - Studied a related problem where the probability of observation packet drop depends monotonically on the amount of energy the sensor draws from an energy harvester. The objective is to design a jointly optimal sensor energy allocation and optimal control policy for minimizing a finite horizon LQG control cost.
  - Showed that the separation principle holds and the design of the optimal controller and the optimal energy allocation can be separated in the case of perfect channel feedback.
- **Stochastic Inventory Control | Research Intern** *May 2019 - July 2019*
  Advisor: Dr. Aditya Paranjape, Tata Research Development and Design Centre
  Introduction: A warehouse has to maintain inventory to meet an unknown stochastic demand process. The objective is to formulate an order placing scheme for our warehouse to minimize the given cost model. Proposed two methodologies: one based on demand modelling and second on learning an order placing policy through simulation using RL based techniques.
  - Developed a Kalman filter based solution to estimate a latent Gaussian model through the output demand process. The order placing policy under this heuristic equals the demand predicted for the day through the learnt model.
  - Interpreted the inventory dynamics as a Markov decision process and employed SARSA and Q-learning based solutions through value function approximation to learn the order placing policy.
  - Trained and evaluated proposed algorithms on various models of the unknown demand process.

SCHOLASTIC ACHIEVEMENTS

- Awarded **Undergraduate Research Award** (URA01) in recognition of promising research potential
- Accepted into the Systems and Control Department (IDDDP) based on academic record and research experience
- Recepient of the **AP** grade (one person in the batch) for outstanding performance in Compressible Fluid Mechanics
- Secured AA grade in graduate level courses: Optimal Control, Stochastic Optimization and Online Learning

OTHER SELECT PROJECTS

- **Model-based Deep RL controller for Super Mario Bros** *Aug 2019 - Nov 2019*
  Project conducted as a part of the course: Foundations of Intelligent and Learning Agents
  - Performed extensive literature survey on Model-based RL methods and learning without extrinsic rewards.
  - Employed a model architecture inspired from pre-existing work on Curiosity-driven exploration whereby our model is composed of two sub-parts: a curiosity-driven reward generator network and a policy network.
  - Modified the architecture to share weights between the reward generator network and the policy network.
  - Trained the agent using Advantage Actor-Critic (A2C) algorithm on the environment Super Mario Bros and traversed 35% of level-1 solely based on the intrinsic rewards generated by our network.
- **Zap Q-Learning: A Survey** *Jan 2020 - June 2020*
  Research survey conducted as a part of the graduate level course: Introduction to Stochastic Optimization
  - Surveyed papers on Zap Q-learning, a matrix gain algorithm with improved asymptotic covariance and speed of convergence than Watkin's Q-learning algorithm.
  - Studied dependance of asymptotic covariance on matrix-gain sequence and the two time-scale update equation.

- **Regret Minimization for Correlated Multi-armed Bandits** *Jan 2020 - June 2020*
  Research project conducted as a part of the graduate level course: Online Learning
  - Correlated bandit setting is one in which rewards produced by each arm are deterministic functions of a common latent source of randomness as opposed to independent and identically distributed rewards.
  - Proposed new algorithms for the purpose of regret minimization in the correlated bandit setting based on latent distribution learning of the hidden source through the generated reward sequence.
  - Compared performance to standard algorithms like the UCB algorithm and obtained better empirical results.

MENTORSHIP EXPERIENCE

- **Student Mentor | Department Academic Mentorship Program** *May 2018 - Apr 2019*
  - Selected on the basis of academic record, ethics and peer review to help sophomore students accelerate their academic performance and ease transition into the department.
  - Participated in a mentorship training program conducted by the Tata Institute of Social Sciences.

RELEVANT COURSEWORK & PROGRAMMING SKILLS

Control & Optimization	Optimization, Games & Information, Optimal Control, Stochastic & Networked Control, Linear Systems Theory
Probability & Learning	Advanced Stochastic Processes, Online Learning, Stochastic Optimization, Intelligent and Learning Agents
Miscellaneous	Data Structures & Algorithms, Machine Learning, High Performance Scientific Computing, Flight Mechanics, Navigation & Guidance
Languages & Tools	C++, Python, Bash, Git, PyTorch, OpenMP, MPI

MISCELLANEOUS PROJECTS

- **Parallel Computing for N-Body Simulation** *Jan 2018 - May 2018*
  Project conducted as a part of the course: High Performance Scientific Computing
  - Developed a program in C++ to simulate the trajectory of n-bodies under their mutual gravitational force.
  - Parallelized the code with OpenMP and MPI and analyzed performance for varying number of bodies ($n = 128$, 1024 and 8096), varying number of threads and processes and varying time-steps of simulation.
- **Controller Design** *July 2018 - Nov 2018*
  Project conducted as a part of the course: Introduction to Control Theory
  - Designed a PD controller in frequency domain using tools like the Bode plot, Nichols chart and the Nyquist plot to achieve required specifications of phase margin and bandwidth for a fourth order system.
  - Simulated the design on MATLAB and validated the results with theoretical predictions.
- **Dimensionality Reduction using Autoencoders** *Jan 2019 - May 2019*
  Project conducted as a part of the course: Machine Learning for Remote Sensing
  - Compared PCA (linear) to a single hidden-layer autoencoder (non-linear) as latent space learning tools.
  - Implemented and compared various autoencoders (Contractive, Variational etc.) on the MNIST dataset.
  - Visualized and studied the effect of the KL divergence term on the latent space learnt by the VAE model.

REFERENCES

Prof. Ankur Kulkarni	**Prof. Jayakrishnan Nair**	**Dr. Aditya Paranjape**
Systems and Control, IIT Bombay	Electrical Engineering, IIT Bombay	TCS Research Pune
Associate Professor	Associate Professor	Scientist
webpage ⋄ email	webpage ⋄ email	webpage ⋄ email