Siddharth Chandak | CV

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Research Interests: Probability, optimization, statistics machine learning, learning theory, and communication.
Current Projects: Multi-agent control, reinforcement learning and stochastic approximation.

Education

- **Stanford University** — **Stanford, CA, USA**
  PhD, Electrical Engineering, Advisor: Prof. Nick Bambos — *2021–present*
- **Stanford University** — **Stanford, CA, USA**
  MS, Electrical Engineering, GPA: 4.15/4 — *2021–2023*
- **Indian Institute of Technology Bombay** — **Mumbai, India**
  Bachelor of Technology in Electrical Engineering, CPI 9.89/10 — *2017–2021*
  - President of India Gold Medal
  - Honours in Electrical Engineering & Minor in Computer Science

Academic Achievements

- Recipient of the **3Com Corporation Stanford Graduate Fellowship**.
- **President of India Gold Medal** at IIT Bombay for best academic standing in B.Tech. in 2021.
- **Prof. K. C. Mukherjee Award** at IIT Bombay for best B.Tech. project among EE students in 2021.
- Among the **top 50** candidates in the **Indian National Olympiads in Chemistry and Physics** and chosen to attend respective **Selection Camps** for **International Olympiads** in 2017.
- **All India Rank 346** in JEE Advanced 2017 among 220,000 students.
- **All India Rank 73** in JEE Main 2017 among 1.18 million students.
- Recipient of **KVPY Fellowship** by Govt. of India with an **All India Rank 86** in 2016.
- **NTSE** Scholar (National Talent Search Exam conducted by NCERT, Govt. of India) since 2015.

Publications

Conference

- S. Chandak, I. Bistritz and N. Bambos, "Tug of Peace: Distributed Learning for Quality of Service Guarantees," to be presented at *2023 IEEE Conference on Decision and Control (CDC)*.
- S. Chandak, I. Bistritz and N. Bambos, "Equilibrium Bandits: Learning Optimal Equilibria of Unknown Dynamics," *2023 International Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, 2023, pp. 1336-1344.

Journal

- S. Chandak, V. S. Borkar and H. Dolhare, "A Concentration Bound for LSPE(λ)", in *Systems and Control Letters*, vol. 171, 105418, Jan. 2023.
- S. Chandak, V. S. Borkar and P. Dodhia, "Concentration of Contractive Stochastic Approximation and Reinforcement Learning", in *Stochastic Systems*, vol. 12:4, pp. 411-430, Dec. 2022.
- S. U. Haque, S. Chandak, F. Chiariotti, D. Gündüz and P. Popovski, "Learning to Speak on Behalf of a Group: Medium Access Control for Sending a Shared Message," in *IEEE Communications Letters*, vol. 26, no. 8, pp. 1843-1847, Aug. 2022.
- V. S. Borkar and S. Chandak, "Prospect-theoretic Q-learning", in *Systems and Control Letters*, vol. 156, 105009, Oct. 2021.
- S. Chandak, F. Chiariotti and P. Popovski, "Hidden Markov Model-Based Encoding for Time-Correlated IoT Sources", in *IEEE Communications Letters*, vol. 25, no. 5, pp. 1463-1467, May 2021.

Preprints

- S. Chandak, P. Shah, V. S. Borkar and P. Dodhia, "Reinforcement Learning in Non-Markovian Environments", *arXiv (2022)*, 2211.01595. *Submitted to Systems and Control Letters.*

Teaching Experience

Stanford University

Served as course assistant for the following courses:

- ENGR 76: Information Science and Engineering — Spring 2022-23
- MS&E 130: Information Networks and Services — Winter 2022-23

IIT Bombay

Served as undergraduate teaching assistant for a batch of 50 freshmen, conducting weekly tutorial sessions, special doubt sessions, and grading answer sheets for the following courses:

- MA106: Linear Algebra — Spring 2019-20
- MA105: Calculus — Autumn 2019-20
- PH108: Basics of Electricity and Magnetism — Spring 2018-19
- PH107: Quantum Physics and Applications — Autumn 2018-19

Experience

- **Aalborg University** — May. - Jul. 2021
  Guide - Prof. Petar Popovski, Department of Electronic Systems
  Proposed a multi-agent multi-armed bandit based approach for transmission of a shared message over multiple shared channels while avoiding collision.
- **Aalborg University** — Apr. - Jul. 2020
  Guide - Prof. Petar Popovski, Department of Electronic Systems
  Proposed encoding and decoding scheme for transmitting short IoT packets with time correlation across a noisy channel by modeling source dynamics using Hidden Markov Models.
- **Imperial College London** — May - Jul. 2019
  Guide - Prof. Nick S. Jones, Department of Mathematics
  Investigated the difference between social networks in UK, ICL and "Hackspace" - a smaller technical community at ICL, by analyzing survey data on friendships, and modeling social networks using Stochastic Block Models.

Research Projects

Multi-Agent Control

Guide - Prof. Ilai Bistritz, Tel Aviv University and Prof. Nick Bambos, Stanford University

- **Online Weighted Load Balancing for Resource Allocation Games** [ongoing] — May 2023 - present
  Developed an online learning algorithm using which game manager can ensure convergence of players to a Nash equilibrium which balances the weighted load on each resource by adjusting the price of each resource.
  - Used tools from two time-scale contractive stochastic approximation to prove almost sure convergence to an equilibrium which satisfies constraints and also obtained regret bounds on finite time performance.
  - Simulated the algorithm for applications such as server pricing in data centers and power control game.
- **Quality-of-Service Guarantees for Tug-of-War Games** [IEEE CDC 2023] — Jan. - Mar. 2023
  Developed a fully distributed online learning algorithm which allows players to converge to an equilibrium which satisfies QoS guarantees, i.e., each player has a minimum reward threshold.
  - Used tools from stochastic approximation, O.D.E. theory, and monotone dynamical systems to show convergence to desirable equilibria.
- **Equilibrium Bandits: Optimal Equilibria of Unknown Dynamics** [AAMAS 2023] — Apr. - Oct. 2022
  Proposed a bandit-based algorithm for problems where the system converges to an equilibrium when an action is fixed, and the regret is defined based on the optimal reward at equilibrium.
  - Borrowed intuition from UCB algorithm to develop Upper Equilibrium Concentration Bound (UECB) algorithm which is optimal up to logarithmic factors for our problem.
  - Modeled epidemic control and policy making for multi-agent systems as equilibrium bandits problems.

Reinforcement Learning and Stochastic Approximation

Guide - Prof. Vivek S. Borkar, IIT Bombay

- **Reinforcement Learning in non-Markovian Environments** [submitted to SCL] — Jan. 2022 - May 2023
  Designed a reinforcement learning agent for non-Markovian environments which achieves significant improvements in performance of Deep Q-Network when applied on partially observable systems.

- Explicitly pinned down the error caused by non-Markovianity on both the asymptotic and finite-time performance of Q-learning.
- Proposed an autoencoder-based scheme to approximate conditional laws which leads to error minimization.
- Evaluated our agent on standard partially observable systems from POPGym.

- **Concentration Bounds for Reinforcement Learning and Stochastic Approximation**
  Used novel martingale and Markov chain inequalities to obtain concentration bounds of form "from time n_0 onwards" for reinforcement learning algorithms.
  - Using conditional martingale inequalities to obtain bounds on performance of TD(0) algorithm [ongoing].
  - Used mixing time based Markov chain inequalities for obtaining bounds on LSPE(λ) [SCL].
  - Obtained concentration bounds for contractive SA and asynchronous Q-Learning [Stochastic Systems].

Other Projects

- **Tractable Probabilistic Multimodal Learning** Spring 2022
  Course: Deep Learning for Computer Vision
  Used Probabilistic Circuits and encoder-decoder pairs trained separately for each modality to learn joint distribution over multiple modalities, while allowing for efficient sampling from the joint or any of the conditionals.
- **Improvements to Legendre Memory Units** Spring 2021
  Course: Advanced Machine Learning
  Suggested and empirically evaluated improvements, based on Bernstein polynomials, to Legendre Memory Units, a memory cell for RNNs that stores information across long windows of time.

Selected Courses

- **Probability & Statistics:** Game Theory, Information Theory and Statistics, Statistical Signal Processing, Queuing Systems, Error Correcting Codes, Stochastic Approximation, Advanced Probability and Random Processes, Information Theory and Coding, Data Analysis
- **Machine Learning & Computer Science:** Deep Learning for Computer Vision, Reinforcement Learning, Convex Optimization, Learning Theory, Number Theory and Cryptography, Data Structures and Algorithms, Logic for CS, Computer Networks, Digital Image Processing, Operating Systems
- **Core EE Courses:** Digital Communication, Control Systems, Digital Systems, Microprocessors, Digital Signal Processing, Electronic Devices and Analog Circuits, Electrical Machines and Power Systems
- **Miscellaneous:** Economics, Sociology, Environmental Studies, Complex Analysis, Differential Equations

Technical Skills

- Proficient in: Python, NumPy
- Experience with: C++, PyTorch, VHDL, Assembly, Embedded C, MATLAB