Raaz Dwivedi

Graduate Student, EECS, UC Berkeley · Machine Learning, Artificial Intelligence

(+1) 510-833-1977 | raaz.rsk@berkeley.edu | www.cs.berkeley.edu/~raaz.rsk | rzrsk | raaz-dwivedi

"Theory is the first term in the Taylor series of practice." Thomas Cover

Education

UC Berkeley (University of California, Berkeley) — *Berkeley, USA*

PhD Candidate in Electrical Engineering and Computer Sciences — *Aug. 2015 - Present*

- *Advisors:* Prof. Martin Wainwright and Prof. Bin Yu
- *GPA:* 4.00/4.00
- Focus on Statistical Machine Learning, Neural Networks, Optimization and Monte Carlo methods

IIT Bombay (Indian Institute of Technology, Bombay) — *Mumbai, India*

B. Tech. in Electrical Engineering — *Jul. 2010 - May. 2014*

- *Advisors:* Prof. Vivek Borkar and Prof. Juzer Vasi
- *GPA:* 9.95/10.00
- Graduated with Honors in Electrical Engineering and Minors in Mathematics

Major Research Projects

Developing a Better Understanding of Neural Networks — *Dec. 2018 - Present*

- Ongoing work on understanding the mysterious generalization behavior of deep neural networks for modern datasets, where we are also trying to develop a framework to better understand the effect of choice of datasets and algorithm on the trained neural network

Tractable Inference in Mixture Models — *Dec. 2017 - Present*

- Studied recovery of mixture models in several different settings using Expectation-Maximization algorithm; such settings are very useful in modern big datasets where we often see a clustered structure at subpopulation level
- Provided a framework to derive algorithmic rate of convergence, and provide insight as to when the algorithm may converge slowly; and also provide sharp guarantees for statistical error in estimating the parameter of the underlying model especially when the number of mixtures is unknown

Fast Algorithms for Large Scale Sampling Problems — *Oct. 2016 - Present*

- Designed new sampling algorithms based on interior point methods; provided their theoretical guarantees for generating random samples on convex sets defined by linear constraints; and established their superiority over prior state-of-the-art for the case when the number of constraints is higher than the number of variables
- Analyzed several MCMC algorithms for sampling from unbounded state space, e.g., Metropolis-adjusted Langevin algorithms and the state-of-the-art Hamiltonian Monte Carlo; and established the provable benefits of using the accept-reject step and multiple gradient steps in MCMC algorithms

Going beyond Monte Carlo points — *Dec. 2016 - Aug. 2017*

- Constructed and analyzed efficient online algorithms to reduce the classical $n^{-\frac{1}{2}}$ rate of discrepancy of empirical distribution of a sequence of Monte Carlo samples by sub-selection, and obtain the faster $O(n^{-1})$ rates of Quasi-Monte Carlo sequence of points
- These algorithms rely on the powerful idea of making a careful choice between two options rather than taking a random point two choices and are computationally efficient and the theoretical guarantees hold simultaneously for all stopping times

Achievements & Awards

2017	**US Junior Oberwolfach Fellow**, Mathematisches Forschungsinstitut Oberwolfach	*Germany*
2015	**Berkeley Fellowship**, UC Berkeley	*Berkeley, U.S.A*
2014	**President of India Gold Medal**, IIT Bombay, for being the most outstanding student in the institute	*Mumbai, India*
2014	**Institute Silver Medal**, IIT Bombay, for being the most outstanding student in the department	*Mumbai, India*
2014	**Best B. Tech. Project Award**, IIT Bombay	*Mumbai, India*
2010	**All India Rank 10**, Indian Institute of Technology Joint Entrance Exam (IIT-JEE)	*India*
2010	**All India Rank 46**, All India Engineering Entrance Exam (AIEEE), a million applicants	*India*

Work Experience

Microsoft Research
New England, USA

Research Intern in Machine learning and Statistics group — *May. 2019 - Aug. 2019*

- Studied algorithms for generating super-samples which enable faster than the classical $n^{-\frac{1}{2}}$ rate of approximation with n points deterministically
- Provided theoretical guarantees for these algorithms for a class of reproducing kernel Hilbert spaces

MIST Systems
Cupertino, USA

Research Intern — *May. 2017 - Aug. 2017*

- Researched and developed several ML and AI models for predicting the network throughput (upload/download speed) of a wireless system; identifying the causes affecting it and detecting time series anomalies
- Was part of a team responsible for design and analysis of a machine learning model for locating wireless customers in an indoor environment, based on noisy measurements of Bluetooth signal strength

WorldQuant LLC
Mumbai, India

Senior Quantitative Researcher — *Jul. 2014 - Jul. 2015*

- Responsible for designing new ML models to seek out sources of inefficiencies, and build predictive profitable strategies
- Developed several *low turnover high quality alphas* for trading in the equity market used in daily re-balancing long-short algorithmic trading strategies on US, Europe, Japan and other markets

Academic Activities

Teaching Experience
2011- 2019

- **Spring 2019, UC Berkeley**: *STAT 154, Modern Statistical Prediction and Machine Learning* taught by Prof Bin Yu: Helped in redesigning the class along with one other TA for a class of 140+ students.
- **Spring 2018, UC Berkeley**: *EECS 189, Introduction to Machine Learning* taught by Prof Anant Sahai and Prof Jennifer Listgarten: Co-led a team of 20+ TAs in a class of 350+ students
- **Fall 2011-Spring 2014, IIT Bombay and MHRD India**: Worked as a TA for undergraduate courses on Calculus, Linear Algebra,, Differential Equations, and Physics, in total 9 times at IIT Bombay and once for an online course (for 400+ undergraduate colleges) by Ministry of Human Resource Development of Government of India

Mentorship Experience
2012 - 2019

- **2017-Current, UC Berkeley**: Member of the Berkeley Artificial Intelligence Research (BAIR) undergraduate mentoring program
- **2012-2014, IIT Bombay**: Worked several times as a member of the Institute Mentoring Program (ISMP) for freshman, and the EE Department Academic Mentoring Program (DAMP) team at IIT Bombay from my sophomore year

Graduate Course Work
2015-2016

- **Theory**: High Dimensional Statistics, Convex Optimization Models, Learning and Control, Stochastic Process: Theory and Applications
- **Applied**: Deep Learning, Convex Optimization Algorithms, Statistical Models: Theory and Applications

Selected Publications

Tractable Inference in Mixture Models

- "Instability, Computational Efficiency and Statistical Accuracy", *Under preparation*, **Raaz Dwivedi**, Koulik Khamaru, Nhat Ho, Martin Wainwright, Michael I. Jordan, Bin Yu
- "Singularity, Misspecification, and the convergence rate of EM", *Submitted to Annals of Statistics, arXiv preprint: https://arxiv.org/pdf/1810.00828.pdf*, **Raaz Dwivedi**, Koulik Khamaru, Nhat Ho, Martin Wainwright, Michael I. Jordan, Bin Yu
- "Theoretical guarantees for EM under misspecified Gaussian mixture models", *Advances in Neural Information Processing Systems (NIPS) 32, 2018*, **Raaz Dwivedi**, Koulik Khamaru, Nhat Ho, Martin Wainwright, Michael I. Jordan.

Large Scale Sampling algorithms

- "Fast Mixing of Metropolized Hamiltonian Monte Carlo: Benefits of Multi-Step Gradients" *Submitted to Journal of Machine Learning, arXiv preprint: https://arxiv.org/abs/1905.12247v1.pdf*, Yuansi Chen, **Raaz Dwivedi** Martin Wainwright, Bin Yu
- "Log-concave sampling: Metropolis Hastings Algorithms are fast!", *Conference on Learning Theory, Stockholm, Sweden, July 2018*, **Raaz Dwivedi**, Yuansi Chen, Martin Wainwright, Bin Yu,
- "Fast MCMC algorithms on polytopes", *Journal of Machine Learning Research, 2018*, **Raaz Dwivedi**, Yuansi Chen, Martin Wainwright, Bin Yu
- "The power of online thinning to reduce discrepancy", *Probability Theory and Related Fields, July 2018*, **Raaz Dwivedi**, Ohad N. Feldheim, Ori-Gurel Gurevich, Aaditya Ramdas.

A complete list available at `http://people.eecs.berkeley.edu/~raaz.rsk/publications.html`