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# Aniket Das

Pre-Doctoral Researcher, Google Research

## Education

**Indian Institute of Technology Kanpur** *Jul' 17 - May' 22 (8 Semesters)*
BTech. in **Electrical Engineering**
Second Major in **Mathematics & Scientific Computing**
**Overall GPA : 9.3/10 Mathematics GPA : 9.8/10**

**Aalto University** *Jan' 20 - Dec' 20 (2 Semesters)*
Academic Exchange in Aalto University School of Science
**GPA : 4.78/5**

## Interests

Sampling Algorithms, Markov Chains, Probability, High Dimensional Statistics, Optimization

## Publications

1. **Provably Fast Finite-Particle Variants of SVGD via Virtual Particle Stochastic Approximation**
**Aniket Das**, Dheeraj Nagaraj [$\alpha\beta$]
**Spotlight** *at Neural Information Processing Systems 2023* [NeurIPS'23]
**Oral** *at Optimal Transport and Machine Learning Workshop, NeurIPS 2023*

2. **Utilising the CLT Structure in Stochastic Gradient based Sampling : Improved Analysis and Faster Algorithms**
**Aniket Das**, Dheeraj Nagaraj, Anant Raj [$\alpha\beta$]
*Conference On Learning Theory 2023* [COLT'23]

3. **Near Optimal Heteroscedastic Regression with Symbiotic Learning**
Dheeraj Baby, **Aniket Das**, Dheeraj Nagaraj, Praneeth Netrapalli [$\alpha\beta$]
*Conference On Learning Theory 2023* [COLT'23]

4. **Sampling without Replacement Leads to Faster Rates in Finite-Sum Minimax Optimization**
**Aniket Das**, Bernhard Schölkopf, Michael Muehlebach
*Neural Information Processing Systems 2022* [NeurIPS'22]

5. **NeurInt - Learning Interpolation by Neural ODEs**
Avinandan Bose*, **Aniket Das***, Yatin Dandi, Piyush Rai
**Spotlight** *at DL & Differential Equations Workshop, NeurIPS 2021* [DLDE'21]

6. **TorchGAN: A Flexible Framework for GAN Training and Evaluation**
Avik Pal*, **Aniket Das***
*Journal of Open Source Software 2021* [JOSS'21]

7. **Jointly Trained Image and Video Generation using Residual Vectors**
Yatin Dandi, **Aniket Das**, Soumye Singhal, Vinay P. Namboodiri, Piyush Rai
*Winter Conference on Applications of Computer Vision 2020* [WACV'20]

[$\alpha\beta$] : *indicates alphabetical ordering* * : *indicates equal contribution*

## Experience

**Google Research, Bangalore**
*Pre-Doctoral Researcher, Machine Learning and Optimization (MLO)* *July '22 - Present*

- Working on sampling, spin systems, high dimensional statistics and stochastic optimization.
- Published two papers at COLT 2023 on SGLD and minimax optimal heteroscedastic regression, and one spotlight paper at NeurIPS 2023 on finite particle convergence of SVGD.

**Max Planck Institute for Intelligent Systems, Tübingen** [Remote]
*Internship Advisors : Michael Muehlebach and Bernhard Schölkopf* *July '21 - Dec '21*

- Worked on stochastic minimax optimization and gradient flows for constrained optimization.
- Paper on sampling without replacement for minimax optimization published at NeurIPS 2022.

**Tata Institute of Fundamental Research, Mumbai** [Remote]
*Internship Advisor : Sandeep Juneja* *Apr '21 - Jun '21*

- Worked on instance-dependent lower bounds for PAC learning in Markov Decision Processes and structured stochastic bandits.

## Selected Projects

**Rapid Convergence of Finite-Particle SVGD using Virtual Particles**
*Advisor : Dheeraj Nagaraj, Google Research* ***[NeurIPS'23 Spotlight + OTML'23 Oral]***

- Developed computationally efficient variants of **Stein Variational Gradient Descent (SVGD)** with **provably fast convergence in the finite-particle regime**.
- Obtained the first known gradient oracle complexity for SVGD that exhibits **polynomial scaling in dimension and error tolerance**. Obtained a **double exponential speedup** over prior works.
- Developed a novel and highly general technique for designing **stochastic approximations in the space of measures** that admit an exact finite-particle implementation
- Applied techniques from Wasserstein Gradient Flows, Differential Geometry and Functional Analysis.
- Accepted as a ***Spotlight Paper*** at ***Neural Information Processing Systems (NeurIPS) 2023***. Selected for ***Oral Presentation*** at ***Optimal Transport & Machine Learning Workshop, 2023***.

**CLT Analysis of Stochastic-Gradient Based Sampling**
*Advisor : Dheeraj Nagaraj, Google Research* ***[COLT'23 Paper]***

- Developed novel **non-asymptotic Central Limit Theorems** to analyze the interaction between the stochastic approximation noise and diffusion noise in stochastic-gradient based sampling algorithms.
- Obtained **state of the art convergence rates** for **Stochastic Gradient Langevin Dynamics (SGLD)** under **minimal isoperimetric conditions**.
- Analyzed the **Random Batch Method (RBM)** for simulating Interacting Particle Dynamics and derived **state of the art trajectory-level guarantees** under minimal assumptions.
- Derived the **first known convergence rates** for the **Covariance Correction** heuristic, and proved that it enables faster convergence of SGLD and RBM without added computational complexity.
- Applied techniques from Stochastic Calculus, Markov Chains and Optimal Transport Theory.
- Work is published at ***Conference on Learning Theory (COLT), 2023***.

**Minimax Optimal Heteroscedastic Linear Regression**
*Advisors : Dheeraj Nagaraj and Praneeth Netrapalli, Google Research* ***[COLT'23 Paper]***

- Developed a computationally efficient **Alternating Minimization** algorithm for heteroscedastic linear regression that exhibits **minimax optimal sample complexity** (modulo log factors).
- Designed statistically and computationally efficient algorithms for **linear regression and phase retrieval under the multiplicative noise model**.
- Utilized the spectral properties of rank-deficient Wishart matrices to design a **novel adaptation of LeCam's method** which is robust to infinite mutual information quantities.
- Applied techniques from High Dimensional Statistics, Random Matrices and Information Theory.
- Work is published at ***Conference on Learning Theory (COLT), 2023***.

**Sampling without Replacement for Finite-Sum Minimax Optimization**
*Advisors : Michael Muehlebach and Bernhard Schölkopf, MPI-IS* ***[NeurIPS'22 Paper]***

- Analyzed stochastic gradient minimax optimization algorithms that sample the data points *without replacement* and demonstrated that they lead to faster convergence than uniform sampling.
- Derived **near-optimal rates for Gradient Descent Ascent and Proximal Point Method** under without-replacement sampling for finite-sum strongly monotone variational inequalities.
- Combined **alternating updates** and without-replacement sampling to outperform sampling with replacement for **nonconvex-nonconcave problems** satisfying a two-sided PŁ inequality.

- Rigorously demonstrated the effectiveness of **data ordering attacks** on finite-sum minimization and minimax optimization by deriving **near-optimal rates** under the **Adversarial Shuffling** model.
- Utilized techniques from Game Theory, Variational Inequalities and Nonconvex Optimization.
- Work is published at ***Neural Information Processing Systems (NeurIPS), 2022***.

**Near-Optimal Streaming Heavy Tailed Stochastic Optimization**
*Advisors : Dheeraj Nagaraj and Arun Sai Suggala, Google Research* ***[In Preparation]***

- Rigorously analyzed the popular clipped SGD heuristic for **Heavy-tailed Stochastic Convex Optimization (HT-SCO) in the streaming setting**.
- Proved that clipped SGD nearly achieves the **optimal sub-Gaussian statistical rate** for HT-SCO under smoothness and strong convexity.
- Applied techniques from Stochastic Optimization and High Dimensional Statistics.
- Currently working on extending our results to problems without strong convexity.

## Relevant Coursework

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|---|---|
| **Computer Science** | Introduction to Programming, Data Structures and Algorithms, Advanced Algorithms, Toolkit for Theoretical Computer Science†, |
| **Probability Statistics & ML** | Advanced Probability Theory†, Markov Chains and Mixing Times†, Optimization, Kernel Methods and Learning Theory, Statistical Signal Processing, State Space Models Probabilistic Modelling & Inference, ML for Signal Processing |
| **Mathematics** | Real Analysis, Complex Analysis, Functional Analysis, Topology, Measure Theory, Differential Geometry, Dynamical Systems, Ordinary Differential Equations, Partial Differential Equations, Linear Algebra, Abstract Algebra, Numerical Methods |

† *: Audited Remotely at Tata Institute of Fundamental Research (TIFR), Mumbai*

## Talks

**Sampling Through the Lens of Optimization : Recent Advances and Insights**
MSR-IISc Theory Seminar 2023, EPFL FLAIR Seminar 2024 **[Slides]** **[Video]**

**Utilising the CLT Structure in Stochastic Gradient-Based Sampling**
Conference on Learning Theory 2023 **[Slides]**

**Near-Optimal Heteroscedastic Regression with Symbiotic Learning**
Conference on Learning Theory 2023 **[Slides]**

## Service

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|---|---|
| **Reviewer** | JMLR, NeurIPS 2023, AISTATS 2022, NeurIPS 2021 DLDE Workshop |
| **Co-ordinator** | Special Interest Group in Machine Learning, IIT Kanpur |
| **Project Mentor** | Programming Club, IITK and Stamatics (Math Club), IITK |

## Awards and Honors

**Academic Excellence Award, IIT Kanpur**
**KVPY Scholarship, Govt. of India**