Raghav Somani

Ph.D. candidate in Computer Science & Engineering at
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Advisor: Prof. Sewoong Oh

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Education

- **University of Washington**
  Ph.D. in Computer Science and Engineering — *Sept '19 - Aug '24*
  Advisor: Prof. Sewoong Oh
  Ph.D. thesis: Scaling Limits of Algorithms on Large Matrices
  GPA: 3.90/4
- **University of Washington**
  M.S. in Computer Science and Engineering — *March '22*
  Supervisor: Prof. Sewoong Oh
  GPA: 3.90/4
- **Indian Institute of Technology Guwahati**
  Bachelor of Technology in Mathematics and Computing — *July '13 - June '17*
  Department of Mathematics
  GPA: 9.10/10 (9.30/10 in major courses)

Industry Work Experiences

- **The D. E. Shaw Group - Quantitative Analyst** — *Sept '24 - Present*
- **The D. E. Shaw Group - Quantitative Analyst Ph.D. Intern** — *June '23 - Sept '23*
  Manager: Dr. Austin Benson
  Group: Systematic Equities
  - Identified unique properties in high-dimensional financial time series data and developed principled algorithms to address several data incompleteness problems, leveraging geometric and statistical concepts.
  - Successfully implemented these algorithms across a diverse range of tasks, covering both equities and options datasets, achieving significant improvements over existing methods.
- **Microsoft Research India - Research Fellow** — *July '17 - July '19*
  Advisors: Dr. Praneeth Netrapalli & Dr. Prateek Jain
  Project group - Provable Non-convex Optimization for Machine Learning Problems
  - Analyzed sparse linear regression and compressed sensing algorithms, achieving provable and tight support recovery guarantees relative to the problem's condition number. Spotlight paper accepted at *NeurIPS '18*.
  - Explored the relationships between optimization and generalization in deep neural networks.
  - Characterized statistical properties of SGD noise. Workshop paper accepted at *NeurIPS '19*.
- **Microsoft Research India - Research Intern** — *May '16 - July '16*
  Advisor: Dr. Sreangsu Acharyya
  Project - Recommendation systems
  - Developed a matrix factorization based algorithm to correct non-linear rating distortions while preserving the low-rank and cluster structures of rating matrices.
  - Demonstrated algorithm's superiority on real-world datasets, consistently outperforming state-of-the-art baselines, while ensuring a unique solution despite its non-convex nature. Paper accepted at *WSDM '19 (ACM)*.
- **CAFRAL, Reserve Bank of India - Summer Research Intern** — *June '15 - July '15*
  Advisor: Prof. Nagpurnanand R. Prabhala
  Project - Modeling 'Economic Policy Uncertainty Index' for India
  - Modeled an *Economic Policy Uncertainty Index* for India using newspaper data and Machine Learning.
  - The index exhibited a correlation of 0.61 with the Indian VIX and successfully detected significant national events such as terrorist attacks, political elections, and economic crises.

Selected Publications

Preprints

1. **Path convergence of Markov chains on large graphs** [arXiv]
   S. Athreya, S. Pal, **R. Somani**, and R. Tripathi[#].
   Under review.
2. **Stochastic optimization on matrices and a graphon McKean-Vlasov limit** [arXiv]
   Z. Harchaoui, S. Oh, S. Pal, **R. Somani**, and R. Tripathi[#].
   Under review.

Journal Publications

1. **Gradient flows on graphons: existence, convergence, continuity equations** [paper]
   S. Oh, S. Pal, **R. Somani**, and R. Tripathi[#].
   Journal of Theoretical Probability

Conference Publications

1. **Robust Meta-learning for Mixed Linear Regression with Small Batches** [paper]
   W. Kong, **R. Somani**, S. M. Kakade, and S. Oh.
   Advances in Neural Information Processing Systems (NeurIPS), December 2020.
2. **Meta-learning for mixed linear regression** [paper]
   W. Kong, **R. Somani**, Z. Song, S. M. Kakade, and S. Oh.
   International Conference on Machine Learning (ICML), July 2020.
3. **Support Recovery for Orthogonal Matching Pursuit: Upper and Lower bounds.** [paper]
   R. Somani[*], C. Gupta[*], P. Jain, and P. Netrapalli.
   Advances in Neural Information Processing Systems (NeurIPS), Montréal, Canada, December 2018. **Spotlight**.
4. **Clustered Monotone Transforms for Rating Factorization** [paper]
   R. Somani[*], G. Hiranandani[*], O. Koyejo, and S. Acharyya.
   ACM International Conference on Web Search and Data Mining (WSDM), Melbourne, Australia, February 2019.

Workshop Publications

1. **Gradient flows on graphons: existence, convergence, continuity equations**
   S. Oh, S. Pal, **R. Somani**, and R. Tripathi[#].
   OTML workshop, *Neural Information Processing Systems (NeurIPS), December 2021.*
2. **Non-Gaussianity of Stochastic Gradient Noise** [arXiv]
   A. Panigrahi, **R. Somani**, N. Goyal, and P. Netrapalli.
   SEDL workshop, *Neural Information Processing Systems (NeurIPS), Vancouver, Canada, December 2019.*

[*] - equal contribution, [#] - alphabetical ordering

Please visit (dblp) or (Google Scholar) for a complete list of research publications.

Research Projects

Ph.D. thesis - Scaling Limits of Algorithms on Large Matrices *May '21 - Present*
Reading committee: Prof. Sewoong Oh, Prof. Soumik Pal & Prof. Zaid Harchaoui, University of Washington [Page]

- Demonstrated that iterative algorithms on large finite-dimensional matrices exhibit well-defined analytical scaling limits as step-sizes approach zero and matrix dimensionality grows to infinity, described by processes on infinite exchangeable arrays and McKean-Vlasov type SDEs.
- Developed the theory of gradient flows on graphons.
- Established new metrics on measure-valued graphons (MVGs) to provide natural convergence notions.
- Uncovered a connection between stochastic gradient descent and MCMC sampling, showing that the scaling limits of both are gradient flows on graphons.
- Analyzed feedforward dynamics in linear residual neural networks as depth and width grow to infinity, revealing propagation of chaos and describing neuron evolution as a Gaussian process.

★ Accepted as Ph.D. thesis. [thesis]

Robustness and Meta Learning for Mixed Linear Regression (MLR) *Nov '19 - Mar '21*

Advisors: Prof. Sewoong Oh & Dr. Weihao Kong, University of Washington [Page]

- Analyzed how small-data tasks can compensate for the scarcity of large-data tasks in MLR. [arXiv]
- Tightened conditions using the sum-of-squares method. Worked on the robust subspace estimation. [arXiv]
- Looked into Robust Subspace estimation for mixture distributions under the batch setting.
- ★ Works got accepted at **ICML '20** & **NeurIPS '20** respectively. [video 1, video 2]

Optimization and Generalization in Deep Neural Networks *July '18 - Sept '19*

Advisors: Dr. Prateek Jain, Dr. Praneeth Netrapalli & Dr. Navin Goyal, Microsoft Research [Page 1, Page 2]

- Understanding the dependence of batch-size (stochasticity), over-parameterization, and optimization on the generalization properties of a variety of neural networks on real world data distributions for classification tasks.
- Analyzing the dependence of support separation, number of hidden neurons, ambient dimension of data distribution, number of training points on optimization and generalization of shallow neural networks.
- ★ A work characterizing SGD noise got accepted at the workshop **SEDL '19** at **NeurIPS '19**. [arXiv]

Sparse Regression and Optimal Bounds for Orthogonal Matching Pursuit (OMP) *Sept '17 - June '18*

Advisors: Dr. Prateek Jain & Dr. Praneeth Netrapalli, Microsoft Research [Page]

- Analyzed OMP for the Sparse Linear Regression problem under Restricted Strong Convexity (RSC) assumptions obtaining its support recovery and generalization guarantees. Also provide tight lower bounds for OMP. Our results are the first such matching upper and lower bounds (up to log factors) for *any* Sparse Regression algorithm under RSC assumption.
- ★ Accepted for a **Spotlight** paper presentation at **NeurIPS '18**. [paper, spotlight video]

Clustered Monotone Transforms for Rating Factorization (CMTRF) *May '16 - Aug '18*

Advisors: Dr. Sreangsu Acharyya (MSR India) & Prof. Oluwasanmi Koyejo (Stanford) [Page]

- Implemented and analyzed CMTRF for recommendation systems which performs regression under shared low-rank structure up to unknown monotonic transforms. CMTRF recovers a unique solution under mild conditions and also outperforms other state-of-the-art baselines on 7 benchmark and 2 synthetic datasets.
- ★ Accepted for an oral presentation at **WSDM '19**. [arXiv]

Relevant Courses

General Mathematics	Linear Algebra, Real & Complex Analysis, Measure theory
Probability theory	Advanced Probability, Probability & Random Processes, Optimal Transport
Statistics	Statistical methods and Time series analysis, Advanced Statistical Algorithms
Financial Engineering	Financial Engineering I & II, Stochastic Calculus for Finance, Monte Carlo Simulations, Statistical analysis of Financial data, Computational Finance
Computational science	Scientific Computation, Matrix Computation
Optimization	Theory of Optimization, Variational Analysis, Convex Optimization (Stanford MOOC)
Computer Science	Design and Analysis of Algorithms, Randomized Algorithms, Discrete Mathematics

Scholastic Achievements

2013 Among top 1.7% of all selected candidates (126,000+) in JEE-Advanced (IIT-JEE).
2013 Among top 0.5% of all candidates (1,400,000+) in JEE-Mains.
2013 Among top 0.15% of all candidates (150,000+) in WBJEE.

Professional Responsibilities

1. *Reviewer*: JMLR, NeurIPS '19, NeurIPS '20, ICML '20.
2. *Teaching Assistant*: Machine Learning CSE 446/546 Spring '21, Machine Learning CSE 446 Spring '24.