Tanmay Kumar **Sinha**

Research Fellow, Microsoft Research

Portfolio Github Google Scholar Email

Education

Sept 2024 – Present | **Northwestern University** | **Evanston, Illinois, USA**
PhD. in Computer Science

Aug 2017 – Dec 2022 | **International Institute of Information Technology, Hyderabad** | **Hyderabad, India**
B.Tech. and MS By Research, Computer Science & Engineering | CGPA: 9.26/10

Experience

Aug 2022 – Aug 2024 | **Microsoft Research** | **Bangalore, India**
Research Fellow | Advisors: Dr. Ankit Garg, Dr. Neeraj Kayal
Pre-doctoral Research Fellow working in the Algorithms and Theory group. Worked on problems related to learning algebraic circuits, mathematical analysis of deep learning, and machine learning theory.

Aug 2021 – Aug 2022 | **Center for Security, Theory and Algorithmic Research** | **IIIT Hyderabad**
Research Assistant | Advisor: Dr. Pawan Kumar
Researcher at the CSTAR Lab at IIIT Hyderabad. Worked on problems at the intersection of optimization theory and machine learning.

Select Research Publications

S=In Submission, C=Conference, W=Workshop | Complete List at Google Scholar

[S] **Towards Analyzing Self-attention via Linear Neural Networks**
Pritam Chandra*, Tanmay Kumar Sinha*, Kabir Ahuja, Ankit Garg, Navin Goyal
International Conference on Learning Representations 2024 [**In Submission at ICLR**]

[C] **Learning Arithmetic Formulas in the Presence of Noise: A General Framework and Applications to Unsupervised Learning**
Pritam Chandra, Ankit Garg, Neeraj Kayal, Kunal Mittal, Tanmay Kumar Sinha (alphabetical order)
Innovations in Theoretical Computer Science 2024 [**ITCS**]

[C, W] **Generalized Structured Low-Rank Tensor Learning** [🔗]
Jayadev Naram, Tanmay Kumar Sinha, Pawan Kumar
6th Joint International Conference on Data Science & Management of Data
A short version of this work appeared in the Optimization For Machine Learning Workshop at NeurIPS 2022. [**CODS-COMAD**]

[W] **Do As You Teach: A Multi-Teacher Approach to Self-Play in Deep Reinforcement Learning** [🔗]
Chaitanya Kharyal, Tanmay Kumar Sinha, Sai Krishna Gottipatti, Srijit Das, Matthew E. Taylor
Extended Abstract at AAMAS 2023
A shorter version of this work appeared at the Deep-RL workshop at NeurIPS 2022. [**AAMAS**]

[C] **Nonnegative Low-rank Tensor Completion via Dual Formulation with Applications to Image and Video Completion** [🔗]
Tanmay Kumar Sinha, Jayadev Naram, Pawan Kumar
Winter Conference on Applications of Computer Vision 2022 [**WACV**]

[C] **A Riemannian Approach to Extreme Classification Problems** [🔗]
Jayadev Naram, Tanmay Kumar Sinha, Pawan Kumar
5th Joint International Conference on Data Science & Management of Data [**CODS-COMAD**]

Select Research Projects

Learning Algebraic Circuits in the Presence of Noise Aug'22 - Present

Advisors: Dr. Ankit Garg, Dr. Neeraj Kayal

- Designed, analyzed, and implemented a general framework for solving the broad problem of reconstructing algebraic circuits, or sums of polynomials.
- Proved reconstruction bounds for the algorithm in the smoothed setting, which involved showing lower bounds for singular values of certain linear operators.
- Implemented the algorithms and demonstrated the efficiency of the method for various applications such as tensor decomposition, subspace clustering, learning mixtures of Gaussians, etc.

Analysis Of Transformer Models April'23 - Present

Advisors: Dr. Ankit Garg, Dr. Navin Goyal

- Worked on analyzing the training dynamics and representation capacity of transformer models for simple tasks.
- Proved guarantees on convergence of simple 1-layer transformers on a class of sequence to sequence tasks.
- Investigated the capabilities of transformer models to learn in-context, by considering the mathematically tractable problem of learning linear regression.

Structured Low-Rank Tensor Completion April'21 - May'22

Advisors: Dr. Pawan Kumar

- Designed a fast, scalable algorithm for a general version of the low-rank tensor completion problem, where the task is to recover the full tensor given the value only at a few indices, under the constraint that the tensor is low-rank and has some structural constraints.
- Involved formulation of the problem as a mathematical optimization problem, using optimization theory to construct the dual of the problem and reduce it to an optimization problem on a manifold, and then using Riemannian optimization algorithms for solving this dual problem efficiently.
- Proved bounds on the reconstruction error of the algorithm, under mild constraints on the underlying tensor and the samples provided.
- Implemented the algorithm and demonstrated the efficacy of the method on real world problems such as recommendation systems, image completion, video completion, etc.

Reinforcement Learning in Sparse Reward Environments Using Asymmetric Self-Play Nov'21 - Nov'22

Advisors: Dr. Matthew E. Taylor, Dr. Srijita Das

- Developed a framework for training RL agents in sparse reward, goal-conditioned environments, through the technique of asymmetric self-play.
- Involves training two types of agents - a curriculum-generating teacher agent, and a student agent which learns using the curriculum.
- The teacher agent is rewarded if the student agent is unable to reach the goals the teacher generates. This forces the teacher to generate more complex goals as the student learns, thus generating a viable curriculum.

Honours and Awards

ALA-Cogment Challenge, AAMAS 2022 Won the ALA-Cogment Challenge, AAMAS 2022. Awarded scholarship of 5000CAD.

IIITH Dean's List Academic Award Awarded the Dean's List Academic Award, awarded for academic and research excellence, in each Academic year from 2017-2022.

INMO 2016 Qualified for the Indian National Mathematics Olympiad 2016, with a rank of 16 in the North-Western region.

Megathon Hackathon 2019 Placed 4th among 50+ participating teams from all over the country.

Teaching and Volunteering Roles

Topics in Applied Optimization, IIIT-H *Teaching Assistant* Monsoon 2020, Monsoon 2021

- Designed assignments and exams for the Topics in Applied Optimization course at IIIT Hyderabad.
- Also involved in grading assignemnts and exams, and mentoring students.

Discrete Structures, IIIT-H *Teaching Assistant* Monsoon 2019

- Held tutorial sessions for first-year undergraduate students in the Discrete Mathematics course at IIIT-H.
- Also involved in evaluating assignments and exams.

Help Cell, IIIT-H *Student Volunteer* Monsoon 2019, Monsoon 2020

- Volunteered in the Help Cell for academically struggling students at IIIT-H.
- Conducted tutorial sessions for the Real Analysis course, and mentored students.

Theory Reading Group, IIITH *Volunteer/Speaker* 2018 - 2022

- Volunteered and gave talks in the student-led Theory reading group at IIITH.