Sayak **Chakrabarti**

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Education

Dual BT-MT in Computer Science and Engineering

Kanpur, India

Indian Institute of Technology, Kanpur *Jul 2017 - May 2022*

- **M. Tech CPI - 10.0/10.0** Supervisor- **Prof. Nitin Saxena**
- **B. Tech CPI - 9.0/10.0**

Research Interests

Computational Complexity Theory, Computational Algebra, Pseudorandomness, Error-Correcting Codes

Publications

1. **On algorithms to find p-ordering**
   - Aditya Gulati, **Sayak Chakrabarti**, Rajat Mittal
   - 7-th Annual **Conference on Algorithms and Discrete Applied Mathematics (CALDAM)**, 2021.
   - *submitted to* the special issue of **Discrete Applied Mathematics** dedicated to CALDAM 2021. [*Under Review*]
2. **Graphon Estimation from Overlapping Vertex-Induced Subgraphs**
   - **Sayak Chakrabarti**, Soumendu Sundar Mukherjee
   - *submitted to* the **Journal of Computational and Graphical Statistics (JCGS)**. [*Under Review*]
   - Previous version avaiable at ArXiv.

Research Experience

Root-finding algorithms for multivariate polynomials modulo prime-powers

[M. Tech Thesis]

Prof. Nitin Saxena, IIT Kanpur *Jul 2020- Present*

In this thesis, we explore algorithms to find roots of multivariate polynomials modulo powers of primes. The idea is to lift each root in $\mathbb{F}_p$ step by step to p-adics. In the beginning, I learnt about polynomial factorization, root counting and algebraic geometry, a report of which is available. In order to lift the roots from $\mathbb{F}_p$ to modulo higher powers of p, we store them in ideals $\mathbb{Z}_p[\overline{x}]$ and perform lifting operations. Currently, we are focussing on bivariates, as the techniques used is expected to translate to multivariates as well. This formation of ideal requires several techniques and edge case handling based on the degree and structure of the polynomial. Once this ideal is formed, we can solve simultaneous polynomial equations using algebraic set decomposition and elimination theory. The draft is in preparation.

Multivariate Polynomial Evaluation

Prof. Petteri Kaski, Aalto University *Apr 2021 - Present*

In this project, we are currently looking for ways to find faster algorithms for multivariate batch evaluation using techniques from designer commutative algebra. The idea is motivated from [KU08] where we intended to construct a ring extension by taking modulo an ideal followed by substitution of variables to bring the evaluation back to the base field. I learnt about several techniques in computer algebra and ideals, and used these to construct the required ideal. We axiomatized the properties that need to be satisfied in order to give an intuition on the structure of the ideal we need to form. In this process, we found an idea for improving the algorithm, and are currently working on generalizing the method and formalizing the steps.

Root sets and p-ordering

Prof. Rajat Mittal, IIT Kanpur *Jun 2020 - Sep 2021*

The problem statement is to efficiently decide if a given subset of $\mathbb{Z}/p^k\mathbb{Z}$ is a valid root set. We studied properties of root sets, its connections to p-ordering and methods of counting root sets. This problem of deciding root sets was reduced to a system of inequalities having some non-linear terms, in order to construct a polynomial corresponding to the root set. We are currently working on solving the system of inequalities by iteratively finding the values. In doing so, an efficient algorithm was required for computing p-ordering of roots given in succinct representations using representative roots. The research led to a paper that finds p-ordering of subsets of integers as well as on sets given in succinct form.

Continuous Skolem Problem for higher dimensions

Prof. Joël Ouaknine, Dr. Engel Lefaucheux, Dr. Eike Neumann, MPI-SWS *May 2020 - Jul 2020*

Our goal was to determine the decidability of zeroes of exponential polynomials. We attempted to extend the existing work using Schanuel's conjecture and Leon Ehrenpreis' conjecture to higher dimensions. Semi-algebraic sets and their decompositions were used in our approach. There was an attempt to find a polynomial lower bound of a set representing the zero set. In this process, we gave a parameterization of the set and extended a proposition to continuously extend bounded continuous semialgebraic functions to $\overline{0}$.

Factorization of polynomials modulo prime powers

Prof. Rajat Mittal, IIT Kanpur *Aug 2019-Jun 2020*

The problem of factorization of polynomial modulo prime powers was the focus of this project. We worked on returning a factorization into maximum number of linear factors, and studying the properties of such factors using representative roots and p-ordering. I learnt about several techniques used in factorization of polynomials in fields and rings. Based on our study, we proved a property that gave a factorization algorithm for cubic polynomials modulo p^k using representative roots.

Graphon Estimation from Partially Observed Network Data

Prof. Soumendu Sundar Mukherjee, ISI Kolkata *Dec 2018 - Dec 2020*

We worked on estimating network edge probabilities seen as graphons. This project started with reviewing literature on existing graphon estimation techniques and finding possibilities to extend them. Based on neighborhood smoothing technique, we gave an algorithm called neighborhood smoothing extended that returned probability estimations of edges of partially revealed graphs. Furthermore, we compared our method against some existing methods in simulated graphons and real data, and our algorithm worked better in most.

Linear Cryptanalysis Applied to Logic Locking

Prof. Pramod Subramanyan, IIT Kanpur — *May 2019 - Oct 2019*

We applied an idea based on linear cryptanalysis in an attempt to break logic locking encryptions. Here, I learnt about existing attacks on logic locking, and tested our approach on small benchmark circuits.

Teaching Experience

Tutor, ESC101: Fundamentals of Computing

Instructors: Prof. Swarnendu Biswas and Prof. Hamim Zafar, IIT Kanpur — *Oct 2021 - Present*

- Conducted weekly tutorial sessions to a class of 45 students for clearing doubts and teaching summary of lectures.
- Helped with setting questions for quizzes and labs.

Teaching Assistant, CS203: Probability for Computer Science

Instructor: Prof. Nitin Saxena, IIT Kanpur — *Mar 2021 - May 2021*

- Conducted tutorial sessions, graded exams and assignments of groups of 20 students.

Teaching Assistant, CS202: Logic for Computer Science

Instructor: Prof. Sunil Simon, IIT Kanpur — *Jan 2021 - Feb 2021*

- Graded some questions from exams of a class of about 120 students.

Volunteer, Shiksha Sopan

Sopan School — *Apr 2019 - Mar 2020*

- Volunteered with Shiksha Sopan, an NGO aimed at providing education to economically weaker section of the society.
- Conducted weekly English Grammar classes to children of classes 6-8 with a strength of about 12.

Academic Mentor, MTH101: Single Variable Calculus & MTH102: Linear Algebra and ODEs

Counselling Services, IIT Kanpur — *Aug 2018 - Apr 2019*

- Helped students facing academic problems in mathematics by conducting remedial classes and one-to-one mentorship

Talks & Presentations

Subspace Designs and Error-Correcting Codes

Course: Computational Complexity Theory — *Nov 2021*

Quantum Information Theory and Applications to Local Decoding

Course: Quantum Computing — *Apr 2021*

Towards Mordell's Theorem: A Useful Homomorphism

Course: Arithmetic Geometry — *Nov 2020*

Weierstrass Normal Form

Course: Arithmetic Geometry — *Oct 2020*

Factorization of polynomials modulo prime powers

Undergraduate Project — *Jul 2020*

Honors & Awards

2020	**Research Fellow**, Max Planck Institute of Software Systems
2017	**All India Rank- 181, Joint Entrance Exam, Advanced**, among 200,000 candidates
2017	**All India Rank- 287, Joint Entrance Exam, Main**, among 1.2 million candidates
2017	**State Rank- 10, West Bengal Joint Entrance Exam**, among 150,000 candidates
2017	**Qualified Indian National Physics Olympiad (INPhO)**, among top 34 students selected from India
2016	**Qualified Indian National Mathematical Olympiad (INMO)**, among top 30 students selected from India
2015	**All India Rank- 115, Kishore Vaigyanik Protsahan Yojana**, among 100,000 candidates
2014	**Scholar, National Talent Search Examination**, National Council of Educational Research and Training

Other Professional Activities

Sub-Reviewer | Journal of Number Theory — *Aug 2021 - Sep 2021*

- Sub-reviewed a paper for Journal of Number Theory under the guidance of and edited by Prof. Nitin Saxena

Project Mentor | Association for Computing Activities — *Jan 2019 - Apr 2019*

- Guided a group of first year students in topics of Theoretical Computer Science

Student Guide | Counselling Service — *Jul 2018 - Apr 2019*

- Provided emotional and academic assistance to 4 freshmen and helped them adjust to campus environment

Graduate Courses

Randomized Methods in Computational Complexity,
Algebraic Number Theory,
Computational Number Theory and Algebra,
Geometric Topology,
Modern Cryptology,
Arithmetic Geometry,
Quantum Computing,
Algorithmic Information Theory,
Computational Complexity Theory