Sanghamitra Dutta

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EMPLOYMENT

University of Maryland, College Park   Aug 2022 - present
Assistant Professor in Electrical and Computer Engineering

JP Morgan Chase AI Research, New York   July 2021-July 2022
Research Scientist in Explainable AI Center of Excellence (XAI CoE)

EDUCATION

Carnegie Mellon University   Aug 2015 - May 2021
Ph.D. in Electrical and Computer Engineering   **A. G. Milnes Thesis Award**
Advisor: Prof. Pulkit Grover
Thesis: Strategies for Fair, Explainable, and Reliable Machine Learning Using Information Theory
Committee: Pulkit Grover, Kush Varshney, Jose Moura, Anupam Datta, Alexandra Chouldechova

Indian Institute of Technology, Kharagpur   July 2011 - Aug 2015
B. Tech. in Electronics and Electrical Communication Engineering   **Best Project Award**
Project Advisor: Prof. Arijit De

RESEARCH INTERESTS

The goal of my research is to build the foundations of reliable machine learning, beginning from a fundamental understanding of the challenges in reliability and trust, and carrying them all the way to practice, so that AI can *truly* bring about social good. I am quite excited by the fundamental and transdisciplinary challenges that arise in my research, be it ethical, legal, or computational. I am driven towards addressing these challenges by collaborating with experts across data science, computer systems, policy, and law, bringing in *a novel foundational perspective using tools from information and coding theory, causality, probability theory, and optimization.*

My recent work in algorithmic fairness proposes a systematic quantification of the *legally non-exempt disparity* in machine learning models, bringing together causality and information theory, in particular, an emerging body of work called Partial Information Decomposition. In my prior work, I have examined problems in reliable computing from the lens of coding theory and performance analysis, leading to the emerging area of "coded computing." I have a broad and diverse research experience, and a strong publication track record (with several follow-on works in reputed institutions and 1000+ citations). My work has appeared in machine learning conferences, namely, NeurIPS, ICML, AAAI, AISTATS, BigData, as well as, information-theory-focused venues, namely, ISIT and IEEE Transactions on Information Theory.

INTERNSHIPS

Dataminr   June 2020 - Aug 2020
Manager(s): Alejandro Jaimes, Joel Tetreault
Mentors: Liang Ma, Tanay Saha
Project: Event Extraction for Natural Language Processing Using Graph Neural Networks

IBM TJ Watson Research Center May 2019 - Aug 2019
Manager: Kush Varshney
Mentors: Dennis Wei, Hazar Yueksel, Pin-Yu Chen, Sijia Liu
Project: An Information-Theoretic Perspective on the Relationship Between Accuracy and Fairness

IBM TJ Watson Research Center May 2017 - Aug 2017
Manager: Priya Nagpurkar
Mentors: Prof. Gauri Joshi, Parijat Dube
Project: Quantifying Error-Runtime Trade-Offs for Distributed Stochastic Gradient Descent

University of Alberta, Edmonton May 2014 - Jul 2014
Mentors: Prof. Mrinal Mandal, Prof. Karumudi Rambabu
Project: Improving Buried Object Imaging Using Ultra Wide Band (UWB) Radar

Indian Statistical Institute, Kolkata Dec 2013 - Jan 2014
Mentor: Prof. Sasthi Charan Ghosh
Project: Interlinking of Heterogeneous Wireless Networks in Soft Handover

PUBLICATIONS

Selected Conference Papers

[C12] **S. Dutta**, J. Long, S. Mishra, C. Tilli, and D. Magazzeni. "Robust Counterfactual Explanations for Tree-Based Ensembles". In: *International Conference on Machine Learning (**ICML**)*. July 2022, pp. 5742–5756.

[C11] P. Venkatesh, **S. Dutta**, N. Mehta, and P. Grover. "Can Information Flows Suggest Targets for Interventions in Neural Circuits?" In: *Advances in Neural Information Processing Systems (**NeurIPS**)*. Vol. 34. Dec. 2021, pp. 3149–3162.

[C10] **S. Dutta**, D. Wei, H. Yueksel, P. Y. Chen, S. Liu, and K. R. Varshney. "Is There a Trade-Off Between Fairness and Accuracy? A Perspective Using Mismatched Hypothesis Testing". In: *International Conference on Machine Learning (**ICML**)*. July 2020, pp. 2803–2813.

[C9] P. Venkatesh, **S. Dutta**, and P. Grover. "How else can we define Information Flow in Neural Circuits?" In: *IEEE International Symposium on Information Theory (**ISIT**)*. June 2020, pp. 2879–2884.

[C8] **S. Dutta**, P. Venkatesh, P. Mardziel, A. Datta, and P. Grover. "An Information-Theoretic Quantification of Discrimination with Exempt Features". In: *AAAI Conference on Artificial Intelligence (**AAAI, Oral Presentation**)*. *Notable paper*: This work proposes a novel axiomatic quantification of the legally non-exempt disparity using information theory and causality. Feb. 2020, pp. 3825–3833.

[C7] P. Venkatesh, **S. Dutta**, and P. Grover. "How should we define Information Flow in Neural Circuits". In: *IEEE International Symposium on Information Theory (**ISIT**)*. July 2019, pp. 176–180.

[C6] U. Sheth, **S. Dutta**, M. Chaudhari, H. Jeong, Y. Yang, J. Kohonen, T. Roos, and P. Grover. "An Application of Storage-Optimal MatDot Codes for Coded Matrix Multiplication: Fast K-Nearest Neighbors Estimation". In: *IEEE International Conference on Big Data (**IEEE BigData**)*. Dec. 2018, pp. 1113–1120.

[C5] **S. Dutta***, Z. Bai*, H. Jeong, T. M. Low, and P. Grover. "A Unified Coded Deep Neural Network Training Strategy based on Generalized PolyDot codes". In: *IEEE International Symposium on Information Theory (**ISIT**)*. June 2018, pp. 1585–1589.

[C4] **S. Dutta**, G. Joshi, P. Dube, S. Ghosh, and P. Nagpurkar. "Slow and Stale Gradients Can Win the Race: Error-Runtime Trade-offs in Distributed SGD". In: *International Conference on Artificial Intelligence and Statistics (**AISTATS**)*. Apr. 2018, pp. 803–812.

[C3] **S. Dutta**, V. Cadambe, and P. Grover. "Coded convolution for parallel and distributed computing within a deadline". In: *IEEE International Symposium on Information Theory (ISIT)*. June 2017, pp. 2403–2407.

[C2] **S. Dutta**, V. Cadambe, and P. Grover. ""Short-Dot": Computing Large Linear Transforms Distributedly Using Coded Short Dot Products". In: *Advances on Neural Information Processing Systems (NeurIPS)*. (Notable paper in the emerging field of coded computing with 200+ citations.) Dec. 2016, pp. 2100–2108.

[C1] **S. Dutta** and P. Grover. "Adaptivity provably helps: information-theoretic limits on l_0 cost of non-adaptive sensing". In: *IEEE International Symposium on Information Theory (ISIT)*. July 2016, pp. 1431–1435.

Selected Journal Papers

[J6] **S. Dutta**, P. Venkatesh, P. Mardziel, A. Datta, and P. Grover. "Fairness under Feature Exemptions: Counterfactual and Observational Measures". In: ***IEEE Transactions on Information Theory*** (2021).

[J5] **S. Dutta**, J. Wang, and G. Joshi. "Slow and stale gradients can win the race". In: ***IEEE Journal on Selected Areas in Information Theory*** (2021).

[J4] **S. Dutta***, H. Jeong*, Y. Yang*, V. Cadambe, T. M. Low, and P. Grover. "Addressing Unreliability in Emerging Devices and Non-von Neumann Architectures Using Coded Computing". In: ***Proceedings of the IEEE*** 108.8 (Aug. 2020).

[J3] P. Venkatesh, **S. Dutta**, and P. Grover. "Information flow in computational systems". In: ***IEEE Transactions on Information Theory*** 66.9 (Sept. 2020).

[J2] **S. Dutta***, M. Fahim*, F. Haddadpour*, H. Jeong*, V. Cadambe, and P. Grover. "On the Optimal Recovery Threshold of Coded Matrix Multiplication". In: ***IEEE Transactions on Information Theory*** 66.1 (Jan. 2020).

[J1] **S. Dutta**, V. Cadambe, and P. Grover. ""Short-Dot": Computing Large Linear Transforms Distributedly Using Coded Short Dot Products". In: ***IEEE Transactions on Information Theory*** 65.10 (Oct. 2019).

Other Papers (Peer-Reviewed Workshops/Conferences/Journals/Preprints)

[W9] A. K. Veldanda, I. Brugere, J. Chen, **S. Dutta**, A. Mishler, and S. Garg. "Fairness via In-Processing in the Over-parameterized Regime: A Cautionary Tale". In: *arXiv preprint arXiv:2206.14853* (2022).

[W8] S. Mishra, **S. Dutta**, J. Long, and D. Magazzeni. "A Survey on the Robustness of Feature Importance and Counterfactual Explanations". In: *ICAIF 2021 Workshop on Explainability in Finance* (2021).

[W7] **S. Dutta**, P. Venkatesh, and P. Grover. "Quantifying Feature Contributions to Overall Disparity Using Information Theory". In: *AAAI-22 Workshop on Information-Theoretic Methods for Causal Inference and Discovery* (2021).

[W6] C. Jiang*, B. Wu*, **S. Dutta**, and P. Grover. "An Information-Theoretic Measure for Enabling Category Exemptions with an Application to Filter Bubbles". In: *BIAS Workshop at ECIR* (2021).

[W5] **S. Dutta**, L. Ma, T. Saha, A. Jaimes, and J. Tetreault. "GTN-ED: Event Detection Using Graph Transformer Networks". In: *TextGraphs Workshop at NAACL* (2021).

[W4] **S. Dutta**, Z. Bai, T. M. Low, and P. Grover. "CodeNet: Training Large Scale Neural Networks in Presence of Soft-Errors". In: *ICML 2019 Workshop on Coding Theory For Large-scale Machine Learning Workshop (CodML Workshop, ICML, Spotlight Presentation)*. June 2019.

[W3] M. Fahim, H. Jeong, F. Haddadpour, **S. Dutta**, V. Cadambe, and P Grover. "On the optimal recovery threshold of coded matrix multiplication". In: *Annual Allerton Conference on Communication, Control, and Computing (Allerton)*. Oct. 2017.

[W2] **S. Dutta***, Y. Yang*, N. Wang, E. Pop, V. Cadambe, and P. Grover. "Reliable Matrix Multiplication using Error-prone Dot-product Nanofunctions with an application to logistic regression". In: *Semiconductor Research Corporation TECHCON*. Sept. 2016.

[W1] **S. Dutta** and A. De. "Sparse UltraWideBand Radar Imaging in a Locally Adapting Matching Pursuit (LAMP) Framework". In: *IEEE International Radar Conference*. May 2015.

[* denotes equal contribution]

News/Discussion on My Research

· Participant in the Causality Program at the Simon's Institute in Spring 2022.

· My research on accuracy-fairness trade-offs and creation of ideal datasets featured in an article titled "Teaching an AI to be less biased doesn't have to make it less accurate" in New Scientist.

· My research on fairness with feature exemptions featured in an article titled "Managing necessary bias in AI" in CMU News on Engineering Research.

· My research on coded computing for deep neural network training featured in an article titled, "Strength training deep neural networks," in CMU News on Engineering Research.

· My results on coded computing (including Short-Dot codes and MatDot codes) address problems that have been open for several decades, and thus have received substantial attention from across communities. They have also motivated practical implementations (both within and outside our research group). Of particular mention is CREDENCE which is a software for coded computing that we are developing.

Patents/Invention Disclosures

[P2] P. Grover, H. Jeong, Y. Yang, **S. Dutta**, Z. Bai, T. M. Low, M. Fahim, F. Haddadpour, and V. Cadambe. *Coded computation strategies for distributed matrix-matrix and matrix-vector products.* US Patent App. 16/588,990. 2020.

[P1] P. Dube, **S. Dutta**, G. Joshi, and P. Nagpurkar. *Adaptive learning rate schedule in distributed stochastic gradient descent.* US Patent App. 15/938,830. 2019.

AWARDS, FELLOWSHIPS, HONORS (in reverse chronological order)

Post-Graduate

Simon's Institute Fellowship for Program in Causality.	2021
A.G. Milnes Thesis Award for Best Doctoral Dissertation in CMU ECE.	2021

Graduate

CMU Cylab 2020 Presidential Fellowship.	2020
Oral Paper Presentation at AAAI.	2020
K&L Gates 2019 Presidential Fellowship in Ethics and Computational Technologies.	2019
Axel Berny 2019 Presidential Graduate Fellowship.	2019
Selected to Participate in Women in Data Science and Mathematics Workshop (WiSDM).	2019
Tan Endowed Graduate Fellowship.	2017
Prabhu and Poonam Goel Graduate Fellowship.	2016
Carnegie Institute of Technology Dean's Fellowship.	2015

Undergraduate

Nilanjan Ganguly Memorial Award for **Best Undergraduate Project**.	2015
HONDA Young Engineer and Scientist Award for academic excellence.	2014
MITACS Globalink Research Award to pursue summer internship in Canada.	2014
DAAD Wise Scholarship.	2014
Secured 99.87 percentile in IITJEE, State Rank 1 in AIEEE, Rank 6 in WBJEE.	2011
Qualified the Entrance Exam for Indian Statistical Institute (ISI).	2011
KVPY Fellowship for academic excellence from the Government of India.	2011
Qualified the Regional Mathematical Olympiad (RMO).	2010

CONFERENCE AND INVITED TALKS

Robust Counterfactual Explanations for Tree-Based Ensembles

· International Conference on Machine Learning (ICML).	2022

Strategies for Fair, Explainable, and Reliable Machine Learning Using Information Theory

· Bocconi University.	2022
· Simons Institute.	2022
· University of Maryland.	2021
· University of Michigan.	2021
· University of Southern California.	2021
· Microsoft Rising Stars.	2021
· JP Morgan Chase AI Research.	2021
· Scripps College.	2021

Exempt and Non-Exempt Biases in Recommendation Systems & Decision Making

· New York University.	2021
· Harvard University.	2021
· Fair February, Brown University.	2021
· Data Science Seminar, University of Utah.	2021
· Microsoft Research.	2021
· Google Research.	2020

An Information-Theoretic Quantification of Discrimination With Exempt Features

· AAAI Conference on Artificial Intelligence.	2020
· Experian DataLabs.	2020
· CMU AI for Social Good Symposium.	2020
. Women in Data Science Mini-Symposium (SIAM Conference on Mathematics of Data Science).	2020

Is There a Trade-Off Between Fairness and Accuracy?

· International Conference on Machine Learning (ICML).	2020
· IBM TJ Watson Research Center.	2019

CodeNet: Training Large-Scale Neural Networks in Presence of Soft-Errors

· ICML Coding Theory for Large-scale Machine Learning Workshop.	2019

Reliable Machine Learning Using Unreliable Components

· Modeling and Optimization: Theory and Applications (MOPTA), Lehigh University.	2018
· University of Helsinki, Finland.	2018
· IBM TJ Watson Research Center.	2017

Coded DNN Using Generalized PolyDot codes

· IEEE Symposium on Information Theory (ISIT).	2018

Coded Convolutions

· IEEE Symposium on Information Theory (ISIT).	2017

Adaptivity Provably Helps: Information-Theoretic Limits on The L0 Cost of Non-Adaptive Sensing
· IEEE Symposium on Information Theory (ISIT). 2016
Sparse UltraWideBand Radar Imaging in a Locally Adapting Matching Pursuit (LAMP) Framework
· IEEE International Radar Conference. 2015

TEACHING AND EDUCATIONAL CONTRIBUTIONS

- **Foundations of Machine Learning (ENEE436)** - *Undergraduate Level Course*   Fall 2022 (Upcoming)
  Instructor for this course at University of Maryland, College Park

  Contributions prior to starting a faculty position:

- **New-Age Information Theory (18753)** - *Graduate Level Course*   Spring 2020
  As a *co-instructor* for this course, I contributed to the design and preparation of new course content, taught some lectures, and also prepared new assignments for the course. This course was a redesign of the previously offered course on information theory. Our redesign emphasized on both classical information and coding theory, as well as, emerging bodies of work within information theory, such as, Partial Information Decomposition, and novel applications of information theory to machine learning, fairness, neuroscience, etc., alongside communication.

- **Information Theory (18753)** - *Graduate Level Course*   Spring 2018
  As a *TA* for this course, I taught some lectures and prepared new assignments.

- **Signals and Systems (18290)** - *Undergraduate Level Course*   Fall 2017
  As a *TA* for this course, I taught weekly lectures (recitations) on mathematical concepts particularly relevant for this course. I also contributed to the preparation of new weekly assignments for this course, as well as grading.

- **Foundations of Cloud and ML Infrastructure (18847F)** - *Graduate Level Course*   Fall 2017, 2018, 2019
  I was a *guest lecturer* in this course, and taught some lectures on coded computing.

- **Foundations of Privacy (18734)** - *Graduate Level Course*   Fall 2020
  I assisted in the design of course projects based on the CMU ECE graduate admissions dataset that I have obtained for my research after an Institutional Review Board (IRB) approval.

- **Professional Teaching Certification**   Spring 2018
  I completed the ECE Teaching Assistant Education Program at CMU that consisted of a series of workshops on topics such as, the fundamentals of teaching, diversity, inclusion, and mental health.

MENTORSHIP

Graduate Students

- Faisal Adamu Hamman (Ph.D. student, University of Maryland College Park)

Masters Students

- Capstone Project (Collaboration between JP Morgan and Columbia University)
  Student Collaborators: Xin Ye, Xiong Yue, Yuzhao Pan, Liyi Zhang, Panyu Gao, "Explainability-Informed Fairness," Spring 2022.

- Capstone Project (Collaboration between JP Morgan and Columbia University)
  Student Collaborators: Junzhi Ge, Mohammed Aqid Khatkhatay, Oscar Jasklowski, Xue Gu, Yue Wang, "Causality-Informed Fairness," Fall 2021.

- Utsav Sheth (INI, CMU), "Credence: Algorithm Based Fault Tolerance at Datacenter Scale," Fall 2017 -

Fall 2018.

- Malhar Chaudhuri (ECE, CMU), "Initial Design of Credence for Coded Computing," Fall 2016 - Fall 2017.

Undergraduate Students

- Chenyu Jiang (Visiting Undergraduate Student, CUHK), "Breaking Filter-Bubbles using tools from Fairness with Feature Exemptions," Summer 2019.

- Bowen Wu (Visiting Undergraduate Student, CUHK), "Breaking Filter-Bubbles using tools from Fairness with Feature Exemptions," (Joint Work with Chenyu Jiang) Summer 2019.

- Ziqian Bai (Visiting Undergraduate Student, CUHK), "Coded Computing for Neural Networks," Summer 2017.

PROFESSIONAL ACTIVITIES

Women In Information Theory (WITHITS) Co-Chair

Membership in Professional Societies/Committees

- Member of the Organizing Committee of Energy & Information Systems (EIS) Seminar, ECE, CMU.
- Student Member of Diversity Committee, ECE, CMU.

Reviewing Responsibilities

- Journals: IEEE Transactions on Information Theory, IEEE Transactions on Communications, IEEE Transactions on Signal and Information Processing over Networks (Publons Profile).

- Conferences: IEEE Symposium on Information Theory (ISIT), Advances on Neural Information Processing Systems (NeurIPS), International Conference on Machine Learning (ICML), AAAI Conference on Artificial Intelligence (AAAI), International Conference on Artificial Intelligence and Statistics (AISTATS), ACM Conference on Fairness, Accountability, and Transparency (FAccT).

POSITIONS OF RESPONSIBILITY

President, Indian Graduate Student Association (IGSA), CMU.	2018
Vice President, Indian Graduate Student Association (IGSA), CMU.	2017
General Secretary, Indian Graduate Student Association (IGSA), CMU.	2016
ECE Representative, Graduate Student Assembly (GSA), CMU.	2016-2019

EXTRA-CURRICULAR ACTIVITIES

Dramatics: Member of Druheen (formerly called Bengali Technology Drama Society).
Fine Arts: Qualification from Pracheen Kala Kendra, one of the oldest cultural organizations of India.
Community Service: Volunteer of National Service Scheme (NSS), India.
Mentorship: Associated with the Student Mentorship Program of Student Welfare Group (SWG) at IIT Kharagpur.