PRATEEK GARG

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EDUCATION

Indian Institute of Technology Bombay   Mumbai, India
Dual Degree: B.Tech in Electrical Engineering with M.Tech in Artificial Intelligence and Data Science   *(Grade: **9.1/10.0**)*
Minor in Computer Science & Engineering   *Nov '20 – Jun '25*
Bachelor's & Master's Thesis Advisor : Prof. Sunita Sarawagi
*Received **Undergraduate Research Award** (URA03 - IIT Bombay): Exceptional contributions to scientific research (2025)*
*Received **Excellence in CSE Teaching Assistantship Award**: Advanced Machine Learning Course (Spring 2024)*

RESEARCH INTERESTS

My research interests lie in probabilistic generative modeling, and in the development and evaluation of robust, controllable models that enable reliable machine learning systems for scientific and decision-making applications.

PUBLICATIONS

1. **P. Garg**, L. Nagalapatti, S. Sarawagi, **"From Search to Sampling: Generative Models for Robust Algorithmic Recourse"** accepted to The Thirteenth International Conference on Learning Representations (ICLR 2025)
2. **P. Garg**, S. Sarawagi, **"Diffusion Models with Flexible Inference Time Control"** *(Manuscript in progress)*
3. **P. Garg**, B. Kohli, S. Sarawagi, **"Masked Diffusion Models are Secretly Learned-Order Autoregressive Models"** under review at Workshop on Principles of Generative Modeling (PriGM) @ EurIPS2025
4. S. Nasser, S. Pathak, K. Singhal, M. Meena, N. Gupte, **P. Garg** and A. Sethi, **"Utilizing Radiomic Feature Analysis for Automated MRI Keypoint Detection: Enhancing Graph Applications"** accepted to 11th International Conference on Bioimaging (BIOIMAGING 2024)
5. V. Prasad C, C. White, S. Nayak, P. Jain, A. Shameem, **P. Garg**, G. Ramakrishnan, **"Speeding up NAS with Adaptive Subset Selection"**, accepted at International Conference on Automated Machine Learning (AutoML 2024)

RESEARCH EXPERIENCE

Generalizations of Diffusion Processes on Discrete Spaces   *Jul '25 - Present*
Research Internship | Guide: Prof. Vikas Garg   *School of Science, Aalto University*

   ◇ **Introduction:** *Discrete Diffusion is rapidly developing as a powerful generative modelling paradigm in various domains and holds promise for controllable, non-sequential generation. In this project, we study theoretical properties of different discrete diffusion processes and aim to develop a unified framework to understand them*

   • Established connections between various discrete diffusion processes and classical MCMC methods such as Gibbs sampling
   • Studying theoretical properties such as convergence, mixing times and optimality of different discrete diffusion processes
   • Working on generalizations of stochastic differential equations to study various discrete diffusion processes

Masked Diffusion Modelling with Heterogeneous Noise Schedules   *Mar '25 - Present*
Master's Thesis | Guide: Prof. Sunita Sarawagi   *CSE, IIT Bombay*

   ◇ **Introduction:** *State of the art tabular generative models provide little to no flexibility in the generation process and are expensive to train and sample from. We explore Discrete Diffusion with Absorbing State, for tabular data generation with feature wise noise schedules which enable flexible sampling under various compute budgets*

   • Proved that the diffusion objective is not invariant to the noise schedule per feature for non-conservative discrete scores
   • Showed that the noise schedules define a preferred unmasking order and experimenting with end-to-end learning strategies
   • Designed a strategy to handle both numerical and categorical feature generation as masked reconstruction task

Diffusion Models with Inference-time Control   *Jan '24 – Present*
Master's Thesis | Guide: Prof. Sunita Sarawagi   *CSE, IIT Bombay*

   ◇ **Introduction:** *Diffusion models have demonstrated strong potential in generating high-quality samples across various modalities. Reward guided sampling leverages a reward signal to guide the sampling process of pre-trained diffusion model. We examine the limitations of existing guidance methods and develop novel inference-time algorithms to address them*

   • Investigated existing methods to pinpoint the causes of diversity loss, reward over-optimization, and sampling bias
   • Demonstrated these limitations on synthetic and real datasets and proposed a simple strategy to improve the algorithms
   • Extended classifier-free guidance for diffusion models which enables flexible inference-time control with arbitrary rewards

Diverse and Robust Algorithmic Recourse
Master's Thesis (Paper, Code) | Guide: Prof. Sunita Sarawagi

Mar '24 – Jan '25

CSE, IIT Bombay

- ◇ **Introduction:** *Contemporary recourse methods recommend a single action against adverse outcomes from a decision making model and may even act adversarial to the model. In this project, we instead prioritize user flexibility by providing a distribution over low-cost, robust and plausible recourse actions, enabling more effective and personalized decision-making*
- Designed multiple synthetic datasets to visualize and study failure modes and tradeoffs in existing recourse methods
- Identified a proximal and plausible distribution over recourse instances and designed a strategy to learn this distribution
- Engineered a tabular data generator which demonstrated a state-of-the-art tradeoff between cost, plausibility and validity

Counterfactual Inference and Application to Algorithmic Recourse
Bachelor's Thesis (Report) | Guide: Prof. Sunita Sarawagi

Aug '23 – Mar '24

CSE, IIT Bombay

- ◇ **Introduction:** *A fast adoption of algorithmic methods across industries poses significant challenges. Algorithmic Recourse provides recommendations to individuals adversely affected by an automated system. We analyse the problem from the lens of counterfactual inference, when recommended actions have downstream effects which needs to be accounted for*
- Performed a thorough literature survey on Causal, Counterfactual inference and various applications to machine learning
- Formulated a recourse problem on time series data where current actions affect current as well as future covariates
- Conducted extensive experiments to validate the proposed methods and demonstrated advantages over baselines

Image Registration using Graph Neural Networks
RnD Project (Paper) | Guide: Prof. Amit Sethi

Jan '23 – Nov '23

EE, IIT Bombay

- ◇ **Introduction:** *Image registration involves alignment of different images of the same scene or object, crucial for medical imaging. Classical methods which rely on techniques such as feature matching and intensity-based methods, do not perform well under non-linear complex deformations. We explore GNNs in conjunction with keypoint detection to execute this task*
- Created a novel dataset Medal-Retina consisting of retinal scans to evaluate models and algorithms for image registration
- Experimented with different techniques, augmenting node embeddings with structural information to enhance performance
- Proposed a novel scheme to create multi-scale graph representations to enhance the performance of SuperGlue network

PROFESSIONAL EXPERIENCE

Modem Firmware Intern | **Qualcomm Technologies Inc.** | **WLAN Firmware team**

May '23 – Jul '23

WLAN Firmware team develops the low-level software with stringent latency requirements for Wi-Fi chips

Hyderabad, India

- Improved the existing testing platform written using System-C library, developed for hardware-software co-design
- Utilised GDB to scout bugs and zed a part of code, resulting progression of 30+ testcases on end-to-end testing
- Developed firmware for Wi-Fi ranging feature adhering to IEEE 802.11az standard to support many-to-one ranging

SCHOLASTIC ACHIEVEMENTS

- Received **Excellence in CSE Teaching Assistantship Award** for Advanced Machine Learning Course (Spring 2024) *(2025)*
- Among ∼60, accepted into **Aalto Science Institute Summer Research Programme** among **7200+** applicants *(2025)*
- Received **Undergraduate Research Award** by IIT Bombay for exceptional contributions to scientific research *(2025)*
- Among ∼10, from **18,000+** applicants selected for the **Pre-Doctoral Researcher** Program at **Google Deepmind India** *(2025)*
- Awarded the **Professor Ram Kumar Scholarship** to attend the GAME-ARTS Conference held at IISc Banglore, India *(2024)*
- Accepted into the **Inter-Disciplinary Dual Degree Programme** at Center for Machine Intelligence and Data Science *(2023)*
- Secured an **All India Rank of 762** in JEE Advanced and **2388** in JEE Mains Examinations, among 2 million candidates *(2020)*
- Secured an **All India Rank of 200** in Kishore Vaigyanik Protsahan Yojana(KVPY) Examination, among 100K applicants *(2020)*
- Recipient of prestigious **KVPY Fellowship** by Department of Science and Technology, Government of India *(declined) (2020)*
- Ranked in the national **top 1% in NSEC** among 30,000+ candidates, qualified for Indian National Chemistry Olympiad *(2019)*

TEACHING EXPERIENCE

Head Graduate Teaching Assistant (Spring 2024) & Graduate Teaching Assistant (Spring 2023)
*CS726 - **Advanced Machine Learning** under Prof. Sunita Sarawagi*

CSE, IIT Bombay.

Led a team of 10 TAs to manage a class of 200+ students, designed assignments and guided students in the coursework
Conducted full-length lectures on Causality, Algorithmic Recourse (Spring 2023) and Generative Modelling (Spring 2024)
Undergraduate Teaching Assistant (Spring 2022)
*MA106 - **Linear Algebra** under Prof. Dipendra Prasad*

Mathematics, IIT Bombay.

Assisted the instructors by grading papers, proctoring exams, mentoring students, conducting tutorials and help sessions

Selected Academic Projects

Neural Architecture Search with Structured Sparsity   *May '23 – Oct '23*
Course Project (Code, Paper)| CS769 - Optimization in Machine Learning | Guide: Prof. Ganesh Ramakrishnan   CSE, IIT Bombay
  • Studied the notion of structured sparsity in context of neural networks and regularisation techniques to induce it in NNs
  • Worked on enhancing existing pruning-based Neural Architecture Search, experimenting with structured sparsity
  • Incorporated adaptive subset selection to enhance the efficient use of data and obtained competitive results in the same

Local Augmentation for Graph Neural Networks   *Aug '23 – Nov '23*
Course Project (Code, Presentation) | CS768 - Learning with Graphs | Guide: Prof. Abir De   CSE, IIT Bombay
  • Reproduced the results in the assigned paper and performed experiments to validate the method on other graph tasks
  • Implemented a normalizing-flow based generative model to replace conditional VAE which demonstrated superior results
  • Proposed a probabilistic message-passing scheme based on the paper, to overcome over-smoothing observed in GNNs

Exploring Neural Ordinary Differential Equations   *Aug '23 – Nov '23*
Course Project (Code, Report) | EE782 - Advanced Topics in Machine Learning | Guide: Prof. Amit Sethi   EE, IIT Bombay
  • Explored whether Neural ODEs as continuous depth model has advantage for various applications in machine learning
  • Devised a custom autograd function in torch to implement a differentiable Neural ODE layer for easy experimentation
  • Demonstrated the effectiveness of Neural ODEs on synthetic and real datasets for classification and generative tasks

Multi-armed Bandits and MDP Planning for Game Environments   *Aug '23 – Nov '23*
Course Project (Code, Report) | CS747 - Reinforcement Learning | Guide: Prof. Shivaram Kalyanakrishnan   CSE, IIT Bombay
  • Implemented variants of Thompson sampling and KL-UCB algorithms for solving different multi-armed bandits problems
  • Built a MDP planner module to produce optimal strategies for half-field football offence and a billiards game, using
    value iteration, linear programming, Howard's policy iteration and Monte-Carlo tree search

Visual Explanations for Deep Neural Networks   *Dec '21 – Jan '22*
Guided project (Code, Report) | Winter in Data Science'21 | Analytics Club   UGAC, IIT Bombay
  • Explored different ways of visualising Deep Neural Networks and reviewed literature on attribution methods for images
  • Implemented attribution methods such as Saliency Maps, Occlusion Sensitivity Maps, and Class Activation Maps (CAMs)
  • Demonstrated limitations of CAMs in localising multiple objects with different classes and objects with multiple instances

Technical Skills

Programming Languages: C/C++, Python, Julia, Java, Bash, Assembly{8051,8086}, MATLAB, VHDL
Libraries: Pytorch, PyTorch-Geometric, Tensorflow, Numpy, Pandas, SciPy, Seaborn, SymPy, Scikit-Learn, Matplotlib, Tensorflow
Software: Git, LaTeX, MATLAB, OpenCV, Octave, Docker, SSH, WSL, Quartus, GNU Radio, Jupyter, Keil, AutoCad

Key Coursework

Machine Learning: Advanced Machine Learning, Reinforcement Learning, Optimization for Machine Learning, Distributed Optimization, Online Learning and Optimisation, Learning with Graphs, Deep Knowledge Representation, Game Theory
Computer Science: Logic for Computer Science, Data Structures and Algorithms, Advanced Computer Architecture, Design and Analysis of Algorithms, Algorithmic Mechanism Design, Discrete Structures, Operating Systems, Computer Networks
Electrical Engineering: Matrix Computations, Markov Chains and Queuing Systems, Digital Systems, Signal Processing, Control Systems, Image Processing, Communication Systems & Networks, Digital Signal Processing, Microprocessors, Electronic Design
Mathematics: Calculus, Linear Algebra, Partial Differential Equations, Complex Analysis, Probability and Random Processes

Mentorship and Extracurriculars

Mentorship	• Machine learning (*Summer of Science*): **Guided four students** with suitable resources and material to build a theoretical understanding of the basics of Machine Learning, Deep Learning and Neural Networks • Python Programming: **Mentored 10+ freshmen** for programming contest; Also introduced version control
Technical	• **Secured 1st position** for Hostel-5 in Technical Inter-Hostel General Championship organised by ERC, IITB • Contributed to the **open-source project** xtensor-stack/xsimd, a SIMD intrinsics wrapper library in C++ • **Served as a reviewer** for India's Best UG Research Talents for ResCon, TechConnect 2024 by EnPower, IITB
Volunteering	• **Contributed articles** promoting sustainability to Parivartan-NSS, IITB's Wordpress blog with 125K+ hits • Volunteered for **Abhyuday, social body of IITB,** during the campaign to clean Versova Beach, Mumbai, India