EESHAAN JAIN

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Education

Indian Institute of Technology Bombay — Mumbai, India
*B.Tech in Electrical Engineering and M.Tech in Artificial Intelligence (Cumulative GPA: **9.68/10.0**)* — *Jul '19 – Jun '24 (Expected)*

École Polytechnique Fédérale de Lausanne — Lausanne, Switzerland
*Semester Exchange in Computer Science (Grade: **5.5/6**)* — *Sep '22 – Feb '23*

Research Interests

Machine Learning: Representation Learning, Geometric Deep Learning, Explainable AI, Fair AI, Submodular Optimization

Publications

1. **Eeshaan Jain**, Indradyumna Roy, Abir De, Soumen Chakrabarti, "**Maximum Common Subgraph Retrieval: Combinatorial and Neural Variants**" in progress.
2. **Eeshaan Jain**, Tushar Nandy, Gaurav Aggarwal, Ashish V. Tendulkar, Rishabh K Iyer, Abir De, "**Efficient Data Subset Selection to Generalize Training Across Models: Transductive and Inductive Networks**", accepted for publication at the 37th Conference on Neural Information Processing Systems, 2023.

Research Experience

Neural Models for Maximum Common Subgraph based Graph Retrieval — *Jul '23 - Ongoing*
Dual Degree Project, Guide: Prof. Abir De, Prof. Soumen Chakrabarti — *IIT Bombay*

- ◇ **Introduction:** *Searching for relevant graphs from a corpus has gained recent traction, with advances in designing neural graph retrieval models. However, they show suboptimal performance in MCS based retrieval, and moreover lack interpretability. We aim to design fast and trainable neural functions to approximate the MCS well.*
- Designed **combinatorial** forms of the MCS problem allowing sequential adaptation to **neural optimization**
- Demonstrated the efficacy of the the approach by **outperforming** other methods in **MSE** and **Kendall-Tau** scores

Generalization Bounds and Explainability of Graph Neural Networks — *May '23 - Ongoing*
Research Assistant, Guide: Prof. Vikas Garg, Amauri H. Souza — *Aalto University*

- ◇ **Introduction:** *Theoretical analyses of GNNs has seen some interest recently, however it is restricted due to strict assumptions. We aim to relax them for GNNs and their explanations, and formulate theoretical guarantees of explainability.*
- Derived stronger and tighter **generalization bounds** for different subclasses of message-passing networks
- Connected notions of **robustness**, **generalizability** and **faithfulness** of explanations with extensions to dynamic graphs

Learning to Select a Subset of Training Examples to Generalize Efficient Model Training — *May '22 – May '23*
Bachelor's Thesis-I (with Google AI), Guide: Prof. Abir De, Prof. Rishabh Iyer (UT Dallas) — *IIT Bombay*

- ◇ **Introduction:** *Adaptive data subset selection methods are tailored for a szpecific neural architecture, and fail to generalize over other architectures. We propose* **SubSelNet***, an attention-based subset selection framework which generalizes over the architecture space and selects subsets for unseen architectures quickly.*
- Introduced a **GNN** and **attention-based** model encoder for crude **approximation** of outputs over a set of architectures
- Relaxed the **combinatorial optimization** objective for subset selection on the novel trainable & differentiable selectors
- Demonstrated that our approach constantly **outperformed** other non-adaptive and adaptive subset selection approaches on various datasets and subset sizes in terms of **accuracy**, **subset selection time** and **memory consumption**
- Showed that our approach **outperforms** other methods in subset-based **AutoML** tasks such as **NAS** and **HPO**

Fairness Audits of Black Box Neural Networks — *Jan '23 - May '23*
Bachelor's Thesis-II, Guide: Prof. Abir De — *IIT Bombay*

- ◇ **Introduction:** *A fast adoption of AI-based methods across industries poses signficiant regulatory challenges. "Good" performing models may have biases resulting in performance difference between subpopulations. We work on querying and auditing unknown neural networks to approximate fairness profiles and disallow future fairness manipulations.*
- Approximated fairness of blackbox models through **near-optimal querying** of data points under budget constraints
- Devised an **RL-based algorithm** to sample points through a VAE coupled with a **Gaussian Process** surrogate model
- Introduced a new fairness metric called **Disparity** bridging group and individual fairness notions, and formulated a disparity-minimization-based **greedy optimization** problem to **minimize post-audit manipulation**

Scholastic Achievements

- Awarded the **Undergraduate Research Award** for Bachelor Thesis in Electrical Engineering (*2023*)
- Awarded the **Google Conference Scholarship** and **NeurIPS Scholar Award** for attending NeurIPS (*2023*)
- Awarded the **Institute Academic Prize** for being the top 2 ranks in Electrical Engineering (*2021 & 2022*)
- **Department Rank 1** out of 79 students in the Dual Degree Programme, Electrical Engineering (*2020 – 2022*)
- Awarded the **AP Grade** for **outstanding performance** in Partial Differential Equations and Quantum Chemistry (*2021*)
- Secured an **All India Rank of 355** in JEE Advanced among 0.25 million candidates (*2019*)
- Secured an **All India Rank of 120** in JEE Mains (Engineering) among 1.3 million candidates (*2019*)
- Ranked **top 300 across India** and appeared in the Indian National Chemistry and Astronomy Olympiads (*2019*)
- Ranked in the **national top 1%** in the National Standard Examination in Physics and Chemistry (*2018*)
- Secured an **All India Rank of 100** and received the **KVPY Fellowship** by Department of Science and Technology (*2018*)

Professional Experience

Junior AI Researcher *May '22 - Jul '22*

AWL, Inc. Japan: Core Artificial Intelligence Team *Sapporo, Japan*

- ◇ **Introduction:** *AWL, Inc. (in collaboration with Sony) is the market leader in Deep Learning-based video analytics in Japan*
- Surveyed optimization frameworks based around **model compression, quantized training** and **inference speed-up**
- Implemented novel **hardware-optimized operations** and routines on CPUs using **Apache TVM** to bring down single-image inference times on low-power devices by **8**$\times$ without hurting the metrics of the outputs
- Utilized GPU-based **TensorRT** and **DLA** frameworks with CPU fallbacks to speed up batched inference on Jetson GPUs

Technical Projects

Post-Hoc Out-of-Distribution Detection *Mar '22 - May '22*

Guide: Prof. Sunita Sarawagi (CS 726: Advanced Machine Learning) *IIT Bombay*

- Introduced a scoring function based on the assumption of a **Dirichlet distribution** on the DNN's softmax-ed logits for OOD detection and showed that it could be asymptotically interpreted as an **ensemble** of two positive scoring functions
- Showed that the score already **outperformed** other OOD methods on multiple datasets using **FPR95**, **AUROC** and **AUPR**
- **Reduced** the number of hyperparameters to tune by demonstrating the **efficacy** of marginless loss functions for the task

Efficient Matroid-constraint-based Submodular Maximization *Mar '22 - May '22*

Guide: Prof. Ganesh Ramakrishnan (CS 769: Optimization for Machine Learning) *IIT Bombay*

- Implemented the efficient **Continuous-Greedy** and **Accelerated Continous-Greedy** algorithms in SUBMODLIB to maximize submodular functions under a matroid constraint with $(1 - 1/e - \epsilon)$ guarantees
- Modified the **Pipage-Rounding** subroutine for **efficient translation** of fractional solutions to discrete subsets
- Implemented the **Submodular Welfare Problem** and, **Separable** and **Generalized Assignment Problem**

Sparse Estimation of Epidemic State using Graph Neural Networks *Sep '21 – Nov '21*

Guide: Prof. Abir De (CS768: Learning with Graphs) *IIT Bombay*

- Generated random and **small-world networks** using the Erdös–Rényi, Watts-Strogatz, and Barabási–Albert models
- Implemented the **SIR** contagion model, treating the epidemic as a CTMC, on our graphs to get a **spatio-temporal** dataset
- Performed **node classification** (S/I/R) using **GCNs** by monitoring only a **small subset** of nodes (15% - 25%)

Stock Market Analysis and Price Prediction *Oct'21 – Nov'21*

Course Project (DS203: Programming for Data Science) | Special Mention: Best Project *IIT Bombay*

- Studied the performance of seven sectors of the **Indian stock market** during the first wave of **COVID-19** from Feb-Jun '20
- Performed **EDA** on the NIFTY sectoral indices and compared them using various **technical indicators** such as RSI
- Compared performance of **sequential neural architectures** such as LSTMs and 1D CNNs to **predict stock market prices**

Non-Small Cell Lung Cancer Detection and Mutation Prediction *Jan '21 - Apr '21*

Guide: Prof. Amit Sethi (Rnd Project) *IIT Bombay*

- Trained the **Inception v3** network on whole-slide FFPE images obtained from The Cancer Genome Atlas Program and Tata Memorial Center to automatically **classify** the tissue sample into LUAD, LUSC or non-cancerous
- Obtained an **AUC score** of 0.97 on cancer classification comparable to the predictions obtained by **pathologists**
- Further trained the network to predict 6 most common **mutated genes** in **LUAD** obtaining a **maximum AUC score** of 0.84

Hyperloop Pod Subscale Design *Jan'20 – Dec'20*

Team Hyperloop IITB *IIT Bombay*

- Applied knowledge acquired on **I2C** and **CAN** communication protocols to the Hyperloop communication systems
- Qualified in the **top 5** university teams internationally for the finals of the **European Hyperloop Week** (EHW 2021)

Autonomous Garbage Collecting Bot *May'20 – Jul'20*
Institute Summer Technical Project | Best Project Award *IIT Bombay*

- Designed an **autonomous** garbage collecting bot which can **classify**, **detect**, **collect** and **segragate** various types of trash
- Used **YOLO** for object detection, **ROS** for simulation, and designed a custom **palming action** gripper for easy collection

Technical Skills

Programming Languages: Python, Scala, C++, Julia, HTML, CSS, Javascript
Machine Learning: PyTorch, PyTorch-Geometric, NLTK, Scikit-Learn, OpenCV, TVM, TensorRT
Software: Scilab, MATLAB, Quartus, Keil, Blender, Git, AutoCAD, SolidWorks, GNU Radio, Spice
Python Libraries : NumPy, Pandas, Matplotlib, Seaborn, SciPy, Qiskit, SymPy, PyQt5, JAX, NetworkX, OpenCV

Teaching Experience

Teaching Assistantships | IIT Bombay
Facilitating smooth course organization, grading papers, mentoring students, conducting tutorials and help sessions

- **CS 768: Learning with Graphs**, Prof. Abir De, Department of Computer Science *Fall 2023*
- **CS 769: Optimization for Machine Learning**, Prof. Ganesh Ramakrishnan, Department of Computer Science *Spring 2022*
- **MA 207: Partial Differential Equations**, Prof. Amiya K Pani, Department of Mathematics *Fall 2021*
- **MA 108: Ordinary Differential Equations**, Prof. Prachi Mahajan, Department of Mathematics *Spring 2020*
- **CH 107: Quantum Chemistry**, Prof. Arindam Chowdhury, Department of Chemistry *Fall 2020*

Python is Cool, Kids | Student-run Summer Course

- Conducted a summer course for **Practical Python Programming**, consisting of interactive live lectures and guided projects, with **1000+ enrollments**

Key Coursework

Machine Learning: Programming for Data Science, Introduction to Machine Learning, Learning with Graphs, Foundations of Intelligent Learning Agents, Advanced Machine Learning, Optimization for Machine Learning, Natural Language Processing†

Electrical Engineering and Computer Science: Probability and Random Processes, Signal Processing, Microprocessors, Electromagentic Waves, Communication Systems, Digital Signal Processing, Image Processing, Markov Chains, Operating Systems, Information Theory and Coding†, Automatic Speech Processing†, Functional Programming† († *taken at EPFL)*

Mathematics and Physics: Calculus, Linear Algebra, Partial Differential Equations, Complex Analysis, Quantum Physics

Positions of Responsibility

Institute Student Mentor *May '23 - Ongoing*
Institute Student Mentorship Program, IIT Bombay

- Responsible for guiding **12 freshmen** focusing on their academic, holistic and overall development in the institute
- Selected based on **overall performance** in a rigorous process comprising of interviews, SOP and peer reviews

Department Academic Mentor *May '23 - Ongoing*
Department Academic Mentorship Program, IIT Bombay

- Responsible for mentoring **6 junior undergraduates** to facilitate their smooth onboarding into the curriculum
- **In-charge** of the Department Academic Mentorship Program website and internship portal

Extra Curricular Activities and Other Achievements

Achievements	• Represented IIT Bombay at **Chemenigma** hosted by IISc Bangalore, and stood first overall • Qualified the **LIMIT** exam hosted by ISI Bangalore, and selected for their camp on abstract mathematics • Completed all six levels of **Speed Arithmetic** under IPA, and **stood 2nd** in their national-level competition • **Represented** the school in multiple debate competitions and won the **best speaker** award twice
Volunteering	• Acted as the **Lead Convener** of the Chemistry Club at IIT Bombay promoting the use of **AI in chemistry** • Took **Python** sessions for 30+ undergraduates and graduates at IIT Bombay over the summer
Mentorship	• **Mentored** a team of **4 freshmen** on their project on Automated Indic Sign Language translation • Guided **20+** students on their summer reading project on **Machine Learning** and **Graph Learning**
Others	• Co-founded **AISRG** – the first student reading group on Artificial Intelligence at IIT Bombay • Elected **Class Representative** for the Electrical Engineering department for three consecutive years • Represented IIT Bombay at Inter-IIT Tech Meet for the **high-preparation** Machine Learning problem • Successfully completed an year-long training in **Chess** under **National Sports Organization** • **Acted** in 1 movie, 5 television series and 40+ television advertisements as a child actor