Shivam Patel

patel-shivam.github.io

Education

Indian Institute of Technology Bombay 2020-24 (Expected)
Bachelor of Technology in Electrical Engineering
CPI : 9.63/10; Ranked in top 4% amongst 203 students
Minor in Artificial Intelligence and Data Science

Publications and Preprints

[1] **f-FERM: A Scalable Framework for Robust Fair Empirical Risk Minimization**
Sina Baharlouei, **Shivam Patel**, Meisam Razaviyayn.
Accepted at **ICLR 2024**. doi.org/10.48550/arXiv.2312.03259
Initial work presented at the **OPT-ML Workshop, NeurIPS 2023**.

[2] **An Asymptotic CVaR Measure of Risk for Markov Chains**
Shivam Patel, Vivek S. Borkar.
Under review at IEEE SPCOM 2024.

Scholastic Achievements

- Awarded the **IUSSTF-Viterbi Scholarship** for pursuing summer research at USC Viterbi School by Department of Science & Technology, Govt. of India. One of only **15** selected students across India. *(2023)*
- Awarded an **AP grade** (1^{st}/160 students) in **Data Structures and Algorithms** course *(2023)*
- Accorded the Kishore Vaigyanik Protsahan Yojana (**KVPY**) fellowship by IISc and DST India *(2020)*
- Achieved an All India Rank **219** in **JEE Advanced** among 0.225 million candidates *(2020)*
- Secured an All India Rank **551** in **JEE Main** among 1 million candidates *(2020)*
- Awarded the **National Genius Search Award** by the National Genius Search Foundation *(2017)*
- Stood amongst the **top 460** nationally in the National Standard Examination in Physics (**NSEP**) *(2020)*
- Stood amongst the **top 330** nationally in the National Standard Examination in Astronomy (**NSEA**) *(2020)*

Research Projects

An Asymptotic CVaR Measure of Risk for Markov Chains *June 2023 - Jan 2024*
Guide: Prof. Vivek S. Borkar | Bachelor Thesis *IIT Bombay*

Infinite horizon simultaneous simulation and estimation algorithms for risk measures find applications in finance and control systems. We provide a rare event simulation technique for surrogate formulation of **Conditional Value at Risk (CVaR)** estimation on Markov Cost Processes (MCPs) with initially hidden rewards.

- Designed stochastic update algorithms for **twisted kernel** parameters to emulate risk measures in MCPs with fixed transition probabilities, where average reward converges to asymptotic value of single reward VaR
- Used Gaussian Kernel Density Estimation to estimate density of both deterministic and stochastic rewards, and employed inverse CDF sampling for Value at Risk estimation
- Our algorithm sequentially simulates original MCP for exploring reward profile and concurrently optimises twisted kernel parameters to emulate rare event quantiles, with uniform convergence guarantees

f-FERM: A Scalable Framework for Robust Fair Empirical Risk Minimization *Summer 2023*
Guide: Prof. Meisam Razaviyayn *USC Viterbi School of Engineering*

In-processing fairness measures add fairness violation regularizers to objective functions. We provide the **first provably convergent algorithm** for training objectives imposing independence amongst select input features and outputs. Our work also **handles distribution shift** and provides a robust optimization paradigm.

- Used Legendre-Fenchel Transforms of f-divergence regularizers to provide unbiased gradient estimators with the training objective amenable to mini-batch SGD, ensuring **consistent performance** across all batch-sizes
- Designed robust optimization techniques with l_p norm **uncertainty neighbourhoods** for target distribution
- Conducted experiments on fairness and generalizability applications, **outperforming SOTA methods**

Anomaly Detection in Semi-Periodic Sequential Data *July - December 2022*
Guide: Prof. Nikhil Karamchandani | Research Project *IIT Bombay*

- Worked on time series anomaly detection with unidirectional anomalies in noisy environments
- Adopted a **predictor-discriminator** framework, focusing on accumulator and Gaussian tail discriminators
- Applied **Fourier, LSTM** and **Bidirectional RNN** predictors for time series data with multiple covariates

Electronic Tilt Estimation using Neural Networks *May - July 2022*
Jio CoE for AI | Artificial Intelligence Intern *Reliance Jio Infocomm Ltd., Hyderabad*

- Utilised time-space weighted average of consumer demand data to design Neural Networks for **optimal electronic tilt prediction** of cell tower antennas, for pan-India deployment across metrocities
- Interpreted model predictions using Shapley Additive exPlanations (**SHAP**) and partial dependency plots
- Employed DBSCAN, K-Means and randomly initialised pivot centralization for coordinate feature extraction
- Characterised discrete tilt prediction using regression and classification approaches, obtaining **MAE of 0.59°** through regression model, and **0.07° MAE, 98.4% accuracy** through the classification model

Stochastic Climate Modelling *May - August 2022*
Guide: Prof. Sandeep Juneja | Research Project *Tata Institute of Fundamental Research, Mumbai*

- Studied **Statistical**, **Empirical** and **Dynamical** methods for long and short time-scale climate prediction
- Designed **Ensemble Multiple Linear Regression** and **Projection Pursuit Regression** models for statistical climate prediction, incorporating feature selection based on covariance and climatological arguments
- Explored published literature on dynamic climate modelling, with a special emphasis on modelling the Indian Summer Monsoon Rainfall using local and globalized **General Circulation Models**

Technical Projects

EEG Data Acquisition System *January - April 2023*
Guides: Profs. Siddhartha Tallur, Laxmeesha Somappa | Electronic Design Lab

Won the **Best Project Award** out of 60+ teams for demonstrating an accurate working model

- Designed a **24-channel Electroencephalogram** signal acquisition device with delta-sigma analog-to-digital converters in daisy chaining mode, with two SPI buses and in-house four layer PCB design
- Created an end-to-end product with headgear and electrodes, SD-card and WiFi modules, accelerometer, external daisy interfacing, equipped with six low-power ADS1194 ADCs and a PIC32 family microcontroller

Foundations of Intelligent Learning Agents *July - November 2022*
Prof. Shivaram Kalyankrishnan | Course Assignments

- Implemented **UCB, KL-UCB** and **Thompson Sampling** for sub-linear regret minimization, alongwith **Thompson Subsampling** and **Quantile regret minimization** for finite feedback exploration problems
- Formulated inequality constraints from Bellman Equations for policy evaluation by linear programming
- Executed MDP planning through **Howard's Policy Iteration**, alongwith Value Iteration evaluator

Energy Based Out-of-Distribution Detection *March - April 2023*
Prof. Sunita Sarawagi | CS726 Course Project *Advanced Machine Learning*

- Replicated energy based OOD detection through **Helmholtz Free Energy** and **Gibbs Distribution**
- Used **ranking loss** for in-processing bounded energy learning for maximising energy gap between in and out-of-distribution samples for efficient detection
- Built an LSTM model to differentiate between particular groups of classes in 20newsgroup dataset as OOD

IITB-RISC Microprocessor Design *March - April 2022*
Prof. Virendra Singh | EE309 Course Project *Microprocessors*

- Designed an **8-register, 16-bit RISC** microprocessor with a Turing complete 17 instruction ISA in VHDL
- Developed the **flowcharts** and **datapath structure** for single and multicycle models from scratch
- Simulated the designed microprocessor models on Cyclone-IVE FPGA, implemented on Quartus software
- Utilised **data forwarding** and **stalling techniques** in six stage pipelined microprocessor to obtain a near perfect cycles per instruction ratio of unity, with clock rate adjusted to maximum time consuming step

Machine Learning for COVID-19 Data Analysis *October - November 2021*
Prof. Amit Sethi, Prof. Manjesh K Hanawal | DS203 Course Project *Programming for Data Science*

- Obtained an **R2 score** of **0.854** on total COVID-19 casualty prediction using regularized linear models
- Performed **Hypothesis Testing** by utilising the χ^2 **Contingency Test** to validate the influence of medical parameters on the ICU admission of any patient, across all age groups and chronic illnesses
- Implemented **Multilayer Perceptron Neural Net** to predict the need of ICU admission of any patient based on blood and body parameters, obtaining a prediction **Accuracy** of **90.65%** , with an **F1-Score** of **0.905**

Navigation Using Spiking Neural Networks *July - September 2022*
Guide: Prof. Udayan Ganguly | Summer Undergraduate Research Program, IITB

- Analyzed SNN modules for emulating biological chemotaxis and klinokinesis based navigation in *C. elegans*
- Modelled **biological navigational behaviour** using **Leaky Integrate and Fire (LIF)** spiking neurons

Visualising Deep Neural Networks *Winter 2021*
Winter in Data Science | Analytics Club, IITB

- Explored **Attribution Approach** for interpreting Deep Neural Networks, with a qualitative focus on image recognition neural architectures, by acquiring ground truth labels and studying the model activation maps
- Studied the applications of **Class Activation Maps, Occlusion Sensitivity Maps** and **Saliency Maps** to visualise CNN functioning for intuitive understanding of various image classification and detection algorithms

Positions of Responsibility

Undergraduate Teaching Assistant *January - April 2023*
EE325: Probability and Random Processes | Prof. Nikhil Karamchandani *IIT Bombay*

- Designed topic-specific fortnightly tutorial problem sets and their solutions
- Conducted problem solving sessions for undergraduate students with 37 enrollments

Institute Student Mentor *August 2023 - Present*
Institute Student Mentorship Program *IIT Bombay*

- Mentoring **twelve** freshmen students from EE and CS majors in academic and non-academic aspects
- One of **143** mentors selected from a pool of **386** applicants after peer-review and interview process

Department Academic Mentor *July 2023 - Present*
Department Academic Mentorship Program *IIT Bombay*

- Guiding **six** EE sophomore students in academics and research opportunities in Electrical Engineering dept.
- Contributing to course reviews and structured roadmaps for students interested in different research domains

Selected Coursework

- **Probability and Optimization:** Introduction to Stochastic Optimization, Optimization for Large Scale Machine Learning, Markov Chains and Queuing Systems, Probability and Random Processes
- **Machine Learning and Statistics:** Advanced Machine Learning, Estimation and Identification, Foundations of Intelligent Learning Agents, Introduction to Machine Learning, Programming for Data Science
- **Computer Science:** Data Structures and Algorithms, Design and Analysis of Algorithms
- **Electrical Engineering:** Signal Processing, Control Systems, Electromagnetic Waves, Microprocessors, Communication Systems, Electronic Devices, Digital Systems, Power Engineering, Analog Circuits
- **Mathematics:** Linear Algebra, Calculus, Complex Analysis, Differential Equations
- **Economics:** Industrial Economics, Game Theory and Economic Analysis, Economics

Extracurricular Activities

- **Active birdwatcher** since 7 years, have observed and studied over **250 species of birds**
- Completed **80 hours** of service under **National Service Scheme (NSS)** *2020-21*
- Mentored **5** freshmen students as a part of **Summer of Science** in **Machine Learning** *2022*
- **Madhyama Prathama** in **Musical Arts in Tabla**, Akhil Bharatiya Gandharva Mahavidhyala *2011-16*
- **Head Boy**, Junior School at Hillwoods School, Gandhinagar *2012-13*
- **Competitive skater**, participated in speed and endurance skating tournaments in U-9 category *2008-10*
- **Chess master** in the U-11 and U-13 categories, and participated in various public and privately organised chess tournaments, including **charity events at Blind School, Ahmedabad**