Shaan ul Haque

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Senior Undergraduate, Department of Electrical Engineering, Indian Institute of Technology Bombay

Research Interests: Applied Probability, Reinforcement Learning, Statistical Learning, Machine Learning, Information Theory

Education

Bachelor of Technology, Electrical Engineering, IIT Bombay, CPI: 9.52/10 **2018 — 2022**

- *Minor, Computer Science and Engineering,* IIT Bombay
- *Honours, Electrical Engineering,* IIT Bombay

Intermediate/+2, Science, Delhi Public School, Ranchi, Percentage: 92.7% **2017 — 2018**

Matriculation, Delhi Public School, Ranchi, CGPA: 10/10 **2017 — 2018**

Publications

- **Shaan ul Haque**, S. Chandak, F. Chiariotti, D. Gunduz, P. Popovski,"Learning to Speak on Behalf of a Group: Medium Access Control for Sending a Shared Message". Submitted at IEEE WCNC 2022

Research Experience

A Concentration Inequality for Average Reward Reinforcement Learning (Ongoing) **July 2020-Present**

Guide: *Prof. Vivek Borkar* | *IIT Bombay*

Working on deriving probabilistic bound for iterates in stochastic approximation of average-reward reinforcement learning

- Studied concentration of contractive stochastic approximation and its application in discounted reward algorithms such as Q-learning and TD(0), and brainstormed ideas to extend them for average reward case
- Explored ways to tweak the RVI-Q learning algorithm and use the J-step contraction property of the associated Bellman optimality equation to derive a similar bound on the iterates

Estimation of Joint Probability Distribution from One-Way Marginal (Ongoing) **August 2020-Present**

Guide: *Prof. Ajit Rajwade* | *IIT Bombay*

Developing an algorithm for learning joint PDF represented as mixture of product densities under low sample complexity constraint

- Employed the idea of Canonical Polyadic Decomposition of tensors to model multi-dimensional mixture of product of 1-D densities
- Explored various optimisation algorithms such as Mirror Descent, Successive Projection Algorithm, etc. proposed in recent research work on joint PMF estimation from lower dimensional marginals which can also be extended to the continuous case
- Recovered the joint density by estimating the one-way marginals from random projection of samples and approximating each distribution in the product as linear combination of continuous dictionary atoms

Learning to Speak on Behalf of a Group: Medium Access Control for Sending a Shared Message **May 2020-Sept 2020**

Guide: *Prof. Petar Popovski* | *Aalborg University*; Co-guide: *Prof. Deniz Gunduz* | *Imperial College of London*

Proposed a learning scheme for communication among multiple agents when, at any instant, only a subset of the agents (active agents), sampled from an unknown distribution over agents' set, are observing the state of the system and atleast one of them needs to share the information to blind agents across shared collision channels

- Modeled the problem as a Multi-Armed Bandit for each active agent to decide when to access the channel or remain silent
- Proved the NP-Hardness of the problem by drawing similarities with the Weighted Graph Coloring Problem and also proved sufficiency in searching the optimal policy in the space of deterministic actions only
- Showed, through simulations, the superiority of the learning-based algorithm in minimizing the average probability of collision over the clustering-based heuristic approach which utilizes the knowledge of the actual probability distribution of agents
- Probed the dependence of learning time of the algorithm on the geometrical structure of distribution

Micro-Doppler Effects in RADAR **May 2020-Dec 2020**

Guide: *Prof. V.M. Gadre* | *IIT Bombay*

Studied the RADAR imaging of FM signal perturbations, also called as Micro-Doppler, generated by rotating and vibrating parts in the target and the Inverse-Radon Transform based iterative algorithm to estimate the parameters of Micro-Doppler components

- Improved the accuracy of the given algorithm by exploring factors such as the effects of window length on the concentration measure of the STFT of the FM signal and effects of Ram-Lak, Hann or Cosine filters on inverse radon of the same
- Devised a filter by employing Bessel function of first kind to sift out the estimated Micro-Doppler component from the signal; Theoretically derived the resolution of the filter and tested it on synthetically generated data

Other Technical Projects

Learning to Play Tic-Tac-Toe: *Foundations of Intelligent and Learning Agents* [Fall '21]

- Modelled a tic-tac-toe game as an MDP with appropriate states, actions, rewards and transition probabilities
- Implemented various algorithms like Howard's Policy Iteration, Value Iteration and Linear Programming to find the best policy to be followed by the agent to maximize it's expected winning probability given a fixed stochastic policy of the other player

Deep Learning for Channel Coding via Neural Mutual Information Estimation: *Introduction of Machine Learning* [Spring '21]

- Automatized encoding of messages using Deep Learning for efficiently sending them across a noisy channel
- Designed a pipeline of two neural networks one for encoding raw messages and other for optimizing the Donsker-Varadhan estimator of Mutual Information between input and output of the channel
- Achieved accuracy close to Quadrature Amplitude Modulation(QAM) without any knowledge of statistical properties of the noise

Statistical Compressed Sensing of Gaussian Mixture Models: *Advanced Image Processing* [Spring '21]

- Studied the application of GMMs in reconstructing large sized signals such as images from limited random measurements
- Implemented EM-algorithm to estimate the parameters of signal's probability distribution
- Achieved better performance in image reconstruction as compared to conventional compressed sensing

Temperature Display and Controller: *Electronic Design Lab* [Spring '21]

- Designed a low-cost circuit that can be installed on any air-conditioning device for automatically maintaining temperature at a certain level and displaying it on LCD
- Implemented an on-off controller in the circuit to control the temperature along with proper interfacing with a high power circuit and used PT-51 microcontroller to display the measured temperature.
- Critically analyzed all the error incurred by the measurement devices and their effects on controlling the temperature

Fischer Faces vs Eigen Faces: *Digital Image Processing* [Fall '20]

- Implemented Fischer Faces for face recognition by employing the technique of Fischer Linear Discriminant, compared with PCA based Eigen faces method and analysed the difference in accuracy between cropped and non-cropped images
- Experimented and compared these face recognition algorithms on various face datasets like Yale and CMU Face Database

Product Planning Problem: *Design and Analysis of Algorithm* [Fall '20]

- Developed a code to plan production output of an industry by exploiting two different algorithms, Integer Linear Programming and Dynamic Programming, and studied the dependence of running time of the algorithms on size of input parameters

Autonomous Security Bot: *Institute Technical Summer Project (ITSP)* [Fall '19]

- Developed an autonomous security bot installed with Raspberry-Pi as a microprocessor which could be used as a substitute for security personnel in an industrial or residential complex
- Automated the navigation system of the bot to map the area by employing Wavefront Mapping Algorithm
- Implemented Face Recognition using Local Binary Pattern Histogram algorithm in the bot for the identification of any stranger

Scholastic Achievements

- Awarded **Undergraduate Research Award-01** (URA-01) by IIT Bombay for research on **RADAR Imaging**
- Secured **All India Rank 111** in **JEE Advanced, 2018** among selected 172,000 aspirants
- Bagged a rank of **481** in **JEE Mains, 2018** among 1.2 million students across the whole country
- Stood among the **state wise top 1%** in **National Standard Examination in Chemistry (NSEC)** in 2018
- Recipient of fellowship by the **Indian Institute Of Science (IISc), Bangalore** for clearing **Kishore Vagyanik Protsahan Yojana (KVPY)**
- Selected for scholarship by Government of India for clearing **NTSE (National Talent Search Examination)** in 2016

Key Courses

- **Electrical Engineering-** Digital Communication, Information Theory and Coding, Controls Systems†, Digital Signal Processing, Microprocessors†, Communication Systems†, Electromagnetic Waves, Signal and Systems, Analog Circuits†, Digital Systems†
- **Mathematics and Statistics-** Advanced Probability and Random Processes, Optimisation, Data Analysis and Interpretation, Complex Analysis, Calculus, Linear Algebra, Differential Equations (Ordinary and Partial)
- **Computer Science-** Foundations of Intelligent and Learning Agents, Introduction to Machine Learning, Advanced Algorithms for Image Processing, Design and Analysis of Algorithms, Data Structure and Algorithm, Computer Programming and Utilization†
- **Miscellaneous-** Environmental Studies, Sociology, Economics, Biology

(†- Courses with accompanied lab)

Technical Skills

- **Programming Languages and Libraries-** C++, Python, Tensorflow, NumPy, PuLP, MATLAB
- **Softwares-** GNUPlot, Keil μVision, Scilab, LaTeX, SolidWorks, NgSpice, Quartus, Eagle, AutoCAD, XCircuit

Position of responsibilities

Activity Associate | Green Campus, National Service Scheme(NSS), IITB [Apr '19 - Apr '20]

NSS is the largest student volunteer body in IITB, serving 1 Million+ people nationwide

- Mentored 100+ volunteers with a team of 7 members for the rejuvenation of ecosystem of the institute
- Content Editor for an online forum Prakriti to create awareness about various ongoing environmental issues throughout the world
- Marketing coordinator at Flare-Igniting Social Conscience a pan-India socio-art competition targeting over 25000+ schools and colleges to increase nature awareness among youth
- Maintained NSS Nursery and sensitized the students about the environment by donating saplings to campus students and residents, carrying out sapling collection drives and plantation drives in hostels
- Played an integral role in the coverage of Invisible Humans of IITB, a Facebook series

Extra Curricular Activities

- Participated in Van Mahotsav 2019-Tree Plantation Drive organised by NSS, IIT Bombay
- Completed 80 hours of social work under Green Campus, National Service Scheme, IIT Bombay for preservation of flora and fauna
- Awarded silver medal for achieving 2nd rank in shot put in General Championship (GC), IIT Bombay
- Represented school in Inter School science quiz 2014, Jharkhand State Level, organised by CSIR in Jamshedpur
- Won First Prize in group singing in Pandit Uma Dutt Sharma Sangeet Mahotsav, Jammu
- Participated in painting competition conducted by Jammu and Kashmir pollution board
- Fluent in three languages - English, Hindi, Urdu