Ishan Kapnadak

Curriculum Vitae

Department of Computer Science & Engineering
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Academics

2023–present Pursuing a Master of Science in Computer Science & Engineering from the University of Michigan (GPA: **4.0/4.0**)

2023–2024 Secured **A+** in graduate courses on **Artificial Intelligence**, **Computational Complexity**, and **Randomness & Computation**

2019–2023 Graduated from Indian Institute of Technology Bombay (IIT Bombay) with a Bachelor of Technology in Electrical Engineering, a Minor in Computer Science & Engineering, a Minor in Artificial Intelligence & Data Science (GPA: **9.45/10**)

2021 Conferred with **AP grade** (top **2%**) for advanced performance in **4 courses**, including **Probability and Random Processes**, **Signal Processing**, and **Complex Analysis**

2020 Achieved a **perfect** Semester Performance Index of **10/10** in the third semester

2019 Secured **All India Rank 228** in *IIT-JEE Advanced 2019* among 245,000 candidates

2019 Scored **426/450** marks in the BITSAT examination conducted by **Birla Institute of Technology**

Research Experience

May 2024 – Present — ***Inference on Galaxy Cluster Fields***, *Research Assistant*.
- Developed software to generate hyper-realistic images of galaxy clusters (representative of images from the Dark Energy Survey) using **GalSim** through a physics-informed **generative prior distribution**
- Designed a **successive-downsampling network** in **PyTorch** that uses the pre-existing BLISS variational encoder to detect galaxy clusters in images using **forward amortized variational inference**

Advisors : **Prof. Jeffrey Regier** (Department of Statistics) & **Prof. Camille Avestruz** (Department of Physics), University of Michigan

July 2022 – May 2023 — ***Fixed Budget Pure Exploration in Multi-armed Bandits***, *Bachelor Thesis Project*.
- Formulated an **adaptive any-time** algorithm for pure exploration problem in multi-armed bandits
- Achieved a **decay rate** for the error probability that was within a **universal constant** of the information-theoretic lower bound

Advisor : **Prof. Jayakrishnan Nair**, *Department of Electrical Engineering*, IIT Bombay

May 2022 – July 2022 — ***Micro-Multiphysics Agent-Based Modelling of Human Bone Remodelling, Exploring the Dual Action Effect of Romosozumab***, *Research Internship*.
- Proposed and implemented a mechanism to obtain changes in bone formation and bone resorption post **romosozumab** injection that match bone turnover marker measurements in clinical trials
- Generated 6 months of placebo and romosozumab **in-silico clinical trials** results on 7 biopsies with new **post-menopausal osteoporosis** model and compared bone mineral density trends to previous results
- Analysed the effect of initial biopsy conditions on response to treatment with romosozumab

Advisor : **Prof. Ralph Müller**, *Department of Health Sciences and Technology*, ETH Zürich

May 2021 – August 2021 — ***Vector-Based Navigation in Artificial Agents***, *Research Internship*.
- Trained an agent to perform **path integration** and **vector-based navigation** in a 2D environment using a recurrent neural network, to solve the problem of spatial navigation in artificial agents
- Observed the emergence of **grid cells** and **place cells** in the agent, resembling the neuronal activities in the mammalian entorhinal cortex, supporting neuroscientific theories about spatial navigation

Advisor : **Prof. Zoran Tiganj**, *Department of Computer Science*, Indiana University Bloomington

Technical Projects

Winter 2024 ***Few-Shot Preference-Based RL***, *Course Project*, Machine Learning.

- Implemented a **preference-based** reinforcement learning paradigm that allows an artificial agent to learn a **generalizable reward function** that can be **rapidly adapted** to different tasks
- Experimented with various **meta-learning paradigms** (including REPTILE and Model-Agnostic Meta-Learning) to extensively test the adaptability and efficiency of the algorithm under the different paradigms
- Incorporated a **prior policy** in the adaptation process in the hopes of leveraging prior knowledge to improve the performance and query efficiency of the algorithm

Advisor : **Prof. Honglak Lee**, *Electrical Engineering & Computer Science*, University of Michigan

Fall 2023 ***Time-Space Tradeoffs for Satisfiability***, *Course Project*, Computational Complexity.

- Performed a literature survey on diagonalization proofs for time-space tradeoffs for solving satisfiability
- Studied the proof of Williams' famous result that SAT cannot be solved in $n^{1.8}$ time and $n^{o(1)}$ space

Advisor : **Prof. Mahdi Cheraghchi**, *Electrical Engineering & Computer Science*, University of Michigan

Fall 2023 ***CADMUS: Context-Aware Design for Emoji Use***, *Course Project*, HCI.

- Conducted **contextual inquiry** to discover short-comings in the field of mobile text entry
- Prototyped multiple designs to address the shortcomings faced by users when using **emojis**
- Implemented three new features in **Figma** to allow users to **efficiently** and **intuitively** navigate the emoji keyboard and **learn** the meaning of unfamiliar emojis
- Conducted a **quantitative user study** using **Wilcoxon signed-rank test** with 16 participants to statistically show that our design successfully meets user requirements

Advisor : **Prof. Nikola Banovic**, *Electrical Engineering & Computer Science*, University of Michigan

Fall 2023 ***A Gene Expression Programming Approach to Designing CNN Architectures***, *Course Project*, Foundations of AI.

- Explored the use of **genetic algorithms** in designing CNN architectures for image classification
- Implemented Cartesian Genetic Programming (**CGP**) and Gene Expression Programming (**GEP**)
- Attained a validation accuracy of **81%** using GEP with (1+2) Evolutionary Algorithm

Advisor : **Prof. Mithun Chakraborty**, *Electrical Engineering & Computer Science*, University of Michigan

April 2022 ***Image-to-Image Translation with Conditional GANs***, *Course Project*, Advanced ML.

- Implemented the **pix2pix** architecture for solving the general class of image-to-image translation problems
- Used the pix2pix architecture to learn a loss function adapted to the task and data at hand

Advisor : **Prof. Sunita Sarawagi**, *Department of Computer Science & Engineering*, IIT Bombay

April 2022 ***Image Denoising using Deep CNNs***, *Course Project*, Medical Image Computing.

- Implemented an end-to-end trainable **deep CNN** based on the **VGG network** using PyTorch for **additive Gaussian noise removal**
- Utilized **residual learning** and **batch normalization** to speed up and stabilize training and boost denoising performance
- Trained on the BSDS300 dataset using **mini-batch SGD** with **weight decay**, **momentum** and **MSE residual based loss**

Advisor : **Prof. Suyash Awate**, *Department of Computer Science & Engineering*, IIT Bombay

November 2021 ***Exposing Image Splicing with Inconsistent Local Noise Variances***, *Course Project*, Digital Image Processing.

- Computed local noise variances using dynamic programming to determine whether an image is spliced
- Investigated Canny edge detection and wavelet decomposition as future improvements to the model3

Advisor : **Prof. Ajit Rajwade**, *Department of Computer Science & Engineering*, IIT Bombay

November 2021 ***Applications of Coding Theory in Cryptography***, *Course Project*, Error Correcting Codes.

- Investigated the use of **minimal codewords** in designing secret-sharing schemes with tailored access privileges by representing secret and shares as digits of a q-ary linear code
- Studied the concept of **orthogonal arrays** and how they connect to the construction of **resilient functions**

Advisor : **Prof. Nikhil Karamchandani**, *Department of Electrical Engineering*, IIT Bombay

May 2021 – July 2021 ***Abstract Algebra***, *Summer of Science, IIT Bombay*.
- Undertook a study of **group theory** with an emphasis on the classification of groups
- Studied the theories of **rings**, **fields**, and **extensions**, with an introduction to **Galois theory**

May 2021 ***Deep Reinforcement Learning***, *Course Project*, Machine Learning.
- Implemented a **Double Deep Q-Network** and **Duelling Deep Q-Network** with a convolution neural network to master the popular Atari game, Pong, and achieved the maximum attainable reward of 21
- Investigated **neural episodic control** and **Monte Carlo tree search** as future advancements to the model

Advisor : **Prof. Abir De**, *Department of Computer Science & Engineering*, IIT Bombay

December 2020 ***Detecting Depression Through Tweets***, *Course Project*, Programming for Data Science.
- Explored various **neural network** architectures including **LSTMs**, **BiLSTMs**, **CNNs**, **GRUs**, and **hybrid** models to classify tweets as indicative of depression using data manually scraped from Twitter
- Analysed the performance of classifiers with **word** versus **character** versus **subword-level embeddings**
- Achieved a maximum accuracy of **99.46%** with the subword-level embedding based CNN model and successfully classified Twitter users into one of four risk zones for depression based on their recent tweets

Advisors : **Prof. Amit Sethi**, *Department of Electrical Engineering*, IIT Bombay, **Prof. Manjesh K Hanawal**, *Department of Industrial Engineering and Operations Research*, IIT Bombay

December 2020 ***Arithmetic and Logic Unit***, *Course Project*, Digital Systems.
- Developed and tested a signed 16-bit **Arithmetic and Logic Unit** using **structural VHDL**
- Designed a fast adder with **Kogge-Stone** architecture to compute addition and subtraction operation

Advisor : **Prof. Virendra Singh**, *Department of Electrical Engineering*, IIT Bombay

April 2020 – June 2020 ***Game Theory***, *Summer of Science, IIT Bombay*.
- Analysed mathematical frameworks for modeling **strategic interactions** between groups of people
- Gained exposure to game-theoretic modeling of various real-life scenarios such as **voting**, **auctions**, **stable matchings**, **allocations**, **market competition**, and **evolution**

Technical Skills

Programming	Python, MATLAB, Julia, C++, Bash, HTML, Markdown
Software	Git, LaTeX, Jupyter, PyTorch Lightning
Libraries	NumPy, Pandas, PyTorch, Scikit-Learn, SciPy, Matplotlib, Tensorflow

Teaching Assistantship

Winter, 2021: **MA109: Calculus I**, Department of Mathematics, IIT Bombay.

Fall, 2021: **MA205: Complex Analysis**, Department of Mathematics, IIT Bombay.

Winter, 2020: **MA109: Calculus I**, Department of Mathematics, IIT Bombay.

Relevant Coursework

AI/ML	Programming for Data Science, Introduction to Machine Learning, Foundations of Intelligent and Learning Agents, Digital Image Processing, Advanced Image Processing, Medical Image Computing, Advanced Machine Learning, Foundations of AI
Electrical Engineering	Signal Processing, Probability and Random Processes, Microprocessors, Control Systems, Markov Chains and Queueing Systems, Communication Systems, Error Correcting Codes, Information Theory and Coding, Stochastic Optimisation, Optimisation, Speech Processing
Mathematics	Calculus, Linear Algebra, Complex Analysis, Differential Equations, Game Theory
Computer Science	Computer Programming, Automata Theory, Data Structures and Algorithms, Design and Analysis of Algorithms, Human-Computer Interaction, Computational Complexity, Randomness & Computation, Advanced Programming Languages

Positions of Responsibility

May 2021 – July 2021 **Mentor**, Summer of Science, IIT Bombay.
- Academically mentored and guided three students in their study of Signal Processing, and Probability Theory and Statistics
- Provided adequate resources and references for the above subjects and resolved their doubts and queries

May 2020 – January 2021 **Pronites Coordinator**, Mood Indigo, IIT Bombay, *50th edition of Asia's largest college cultural festival with 100+ events and 100k+ viewership*.
- Worked in a team of **60**, responsible for smooth execution of online concerts in the first ever online Mood Indigo
- Ideated and analysed various models to conduct **Livewire**, a gig series for semi-professional bands, virtually
- Extensively researched and databased **50+** bands to increase participation in Livewire from **10+** cities across India

January 2020 – November 2020 **Junior Controls Engineer**, Hyperloop, IIT Bombay, *50-member team involved in designing and building a fully functional prototype pod for **SpaceX's Hyperloop Competition**, finalist of the European Hyperloop Week*.
- Analysed and studied **error detection and correction** algorithms, and the **I2C communication protocol**
- Worked on designing and implementing a **controller** for the pod using **state-space methods** and **Simulink**

Extracurricular Activities

Music.
- Released an original song on **Spotify** and **Apple Music** and garnered **1200+** streams
- Stood **first** in the Band Competition in the 5th **Inter-IIT Cultural Meet** as part of the Music Contingent
- Stood **second** in the **Music General Championship** representing **Hostel 2** as a **guitarist**
- Represented IIT Bombay in the 4th **Inter-IIT Cultural Meet** as part of the Music Contingent

Sports.
- Successfully completed a year-long **NSO Programme** in **Table Tennis** at IIT Bombay
- Secured **second place** in MSSA Football (Division II) representing Arya Vidya Mandir, Juhu

Miscellaneous.
- Awarded the title of **Arya Kumar**, Arya Vidya Mandir, Juhu, for best overall performer across curricular and extracurricular activities
- Secured second position in school for performance in ICSE examinations
- Appointed **Head Boy** (2016-17) and **Assistant Head Boy** (2015-16), Arya Vidya Mandir, Juhu