

# Jayesh Singla

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## RESEARCH INTERESTS

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Reinforcement learning, Robotics, Statistical machine learning, Cryptography, Computer vision

## EDUCATION

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### Indian Institute of Technology Bombay

GPA - **9.96/10**

Bachelor of Technology with Honors in Computer Science and Engineering

2019-2023

- **Class Rank 2** in a batch of 140 students of the Computer Science department

## INTERNSHIPS/RESEARCH EXPERIENCE

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### Dyna-style adversarial model-based RL

Winter 2021 - present

Research Project | Guide: Dr. Peter Stone and Ishan Durugkar

UT Austin

- Reviewed literature on **model-based and model-free RL** and implemented basic algorithms such as **DQN, A2C**
- Contributed to the development of a novel model learning paradigm based on **adversarial distribution matching**, to be used as part of a Dyna-style model-based algorithm in conjunction with policy-learning algorithms like **PPO**
- Worked on an algorithm inspired by the technique **GARAT** developed by **Desai et. al** which learns the environment dynamics by modeling it as a policy in an **MDP** which is learnt through **on-policy model-free** algorithms
- Using a combination adversarial training and **supervised learning** while seeding the algorithm with suboptimal exploratory policies to **minimize number of agent interactions** with the real environment
- Tested our hypotheses on multiple environments like **Cartpole, Mountain-Car** and some MuJoCo environments

### Question Answering over Knowledge Graphs

Autumn 2022 - present

Bachelors' Thesis | Guide: Prof. Soumen Chakraborti and Prof. Abir De

IIT Bombay

- Surveyed literature on efficient document-retrieval techniques and question-answering over knowledge bases (**KGQA**)
- Exploring deep graph-retrieval which can be efficiently deployed using **CoBERT**-like centroid pruning techniques
- Used GNNs such as message passing networks (**MPNN**) to obtain embeddings for knowledge bases and formulated a scoring function and an **optimization problem** to retrieve the most relevant subgraph for a given query graph
- Testing our algorithm on knowledge bases like **FB15k, NELL** with complex queries generated from templates

### COA-Secure Anonymous Signatures

Autumn 2021 - present

Research Project | Guide: Prof. Manoj Prabhakaran

IIT Bombay

- Modeled **anonymous signatures** in the **Agents framework** developed by Agarwal et. al. by creating a new signature scheme using a generalized signature scheme and a **statistically-binding commitment** scheme
- Modeled an **ideal schema** for the signature setting and theoretically proved that the scheme is **Chosen Objects Attack (COA)**-secure i.e. security against adversarially generated objects
- Proved that the scheme  $\Delta$ -s-IND-PRE secure implementation of the schema using **indistinguishability of hybrids**
- Working on a similar proof to port the idea to **signencryption** - a combination of encryption and signatures

### Pluribus - No Limit Texas Hold'em Poker Superhuman AI

Winter 2020

Reinforcement Learning Intern

Octro Inc.

- Implemented **Linear Monte Carlo Counterfactual Regret Minimisation** with **pruning** for an efficient traversal of the game tree and trained a **blue print strategy** for the abstracted game based on **Pluribus** developed by **CMU**
- Investigated **Hand Isomorphism** for lossless abstraction of information to reduce the size of the game tree
- Implemented **Potential Aware Imperfect Recall Abstraction** to make it feasible to run a search algorithm
- Clustered states using **expected hand strength** and **kmeans++** unified with **Earth Mover's Distance**

### Learned Intrinsic Rewards for Robotic Manipulation

Spring 2022

Research Project | Guide: Prof. Shivaram Kalyanakrishnan

IIT Bombay

- Identified robotic tasks as candidates for intrinsic reward learning due to the sparse nature of rewards
- Experimented with algorithms like **Random Network Distillation, PPO, DDPG** to setup baselines
- Tested the **LIRPG** algorithm on robotic manipulation tasks like the **FetchReach, FetchPickandPlace** tasks
- Proposed a new intrinsic reward formulation for goal-based tasks separating goal-dependent and independent rewards

### PostgreSQL Monitor

Summer 2022

Software Engineering Internship

Optiver Amsterdam

- Built a **real-time database alerting system** in **Python** based on performance metrics such as number of deadlocks, maximum query duration, number of database connections etc using the **PostgreSQL Statistics Collector**
- Incorporated multiple features such as **aggregation, windowing, filtering** to support a variety of checks
- Enhanced application performance using **asyncio** to execute data collection routines and alerting routines concurrently

## Travelling Salesman Problem on Solid Grid Graphs

Research Internship | Guide: Sándor P. Fekete

Summer 2021  
TU Braunschweig

- Investigated and surveyed literature on the **TSP** and the **Longest Cycle** problem in solid grid graphs
- Explored the solution to the **Travelling Salesman Problem** in Solid Grid Graphs by modifying their two factorizations
- Ideated on a **boundary-stripping** algorithm as a candidate solution for the problem on **2-connected** SGGs

## KEY PROJECTS

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### Poisson Denoising using Plug and Play

Course Project: Advanced Image Processing | Guide: Prof. Ajit Rajwade

Spring 2021

IIT Bombay

- Implemented a modified version of the **Plug-and-Play** framework by Rond et. al. with Block Matching and 3-D Filtering(**BM3D**) algorithm as the Gaussian denoiser of choice for the case of **Poisson** denoising in **MATLAB**
- Applied a variant of the technique on Poisson **denoising+deblurring** with **Gaussian**, motion and uniform **kernels**
- Employed **cross-validation** for parameter tuning and techniques like **binning** to improve the **PSNR** by **5 dB**

### Survey of Bandit and MDP Algorithms

Course Assignment: Foundations of Learning Agents | Guide: Prof. Shivaram Kalyanakrishnan

Spring 2022

IIT Bombay

- Experimented with various bandit algorithms like **UCB**, **Thompson Sampling** and implemented them in Python
- Implemented **Value Iteration** & **Howard Policy Iteration** to find the optimal policy for a game "anti-tic-tac-toe"
- Created a **Sarsa(0)** agent for the 'Mountain car' problem and contrasted the performance with a **tile coding** algorithm

### L.A.M.A. AI

Seasons of Code

Summer 2020

IIT Bombay

- Created an **AI** agent to play the **German strategic card game, L.A.M.A.**, obtaining an accuracy of **75%**
- Implemented a **Q-Learning (Reinforcement Learning)** model from scratch in **Python** using **NumPy**
- Experimented with **reward functions** and exploration strategies like **dynamic  $\epsilon$ -greedy** to improve the model

### Traffic Sign Recognition

Inter IIT Technical Meet | Member of the contingent that stood 2nd overall

Spring 2021

IIT Bombay

- Worked in a group of **10** to create a platform to **view, modify and train** neural networks and **visualize** the results
- Added support for interactive **confusion matrix**, real time **accuracy plots** and automated **result suggestions**
- Used the platform to train models on the **GTSRB dataset** having imbalanced data with an accuracy of **95%**

### Image Super-Resolution using Deep Neural Networks

Course Project: Medical Image Processing | Guide: Prof. Suyash Awate

Spring 2022

IIT Bombay

- Worked on the under-determined problem of **recovering the high-resolution image** from a single blurred image
- Implemented **Enhanced Deep Residual Networks (EDSR)** and obtained **PSNR** gain of **9dB** on brain MRIs

### Multiparty Homomorphic Encryption using Ring-LWE

Course Project: Cryptography and Network Security | Guide: Prof. Manoj Prabhakaran

Spring 2021

IIT Bombay

- Learnt about concepts like **Homomorphic Encryption**, multiparty computation and **Ring Learning with Errors**
- Focused understanding the extension of the **BFV encryption scheme** a recent research paper **Multiparty Homomorphic Encryption from Ring-Learning-With-Errors** by Mouchet et. al.
- Composed an extensive report documenting and summarizing the main concepts, algorithms and results

### Kinesic : Go Hands Free!

Institute Technical Summer Project

Summer 2020

IIT Bombay

- Created a **no-cost hardware-free** application to fully control a laptop/PC using **hand gestures and speech**
- Explored the usage of an **end-to-end hand detection** pipeline using **Yolov3** object detection algorithm
- Preprocessed speech and used Google's **speech to text API** and created **word bindings** to simulate keyboard commands

### Resume Verification Portal

Developers Community

Summer 2020

IIT Bombay

- Developed a **website** to **ease the process of verification** of resume points at **IIT Bombay**
- Used **Angular 9** to create pages for students and a **backend API in NodeJS** for login, registration using **Cookie-based session authentication** and point submission, verification and deletion using a **MySQL** database deployed on **Nginx**
- The website was utilized by the **IIT Bombay Placement Cell** and over **4000+** university students

### Red Plag : An Automatic System for Detecting Code Plagiarism

Course Project: Software Systems Lab | Guide: Prof. Amitabha Sanyal

Autumn 2020

IIT Bombay

- Developed a program to compute a pairwise **similarity matrix** using **Cosine distance** given a group of source code files
- Used Inverse Document Frequency (**IDF**) to autodetect keywords and **K-gram** models to encode the preprocessed files
- Built a web application using **Angular+ Django REST** and a **terminal client** in **Node.js** with **session authentication**

## SCLP - Compiler for small C-like language

Spring 2022

Course Project: Implementation of Programming Languages | Guide: Prof. Uday Khedker

IIT Bombay

- Developed a compiler for a subset of C language supporting **conditions, loops, scope levels and control sequences**
- Implemented a lexical analyzer and parser using **lex** and **yacc** to produce an **Abstract Syntax Tree (AST)**
- Translated the AST to **Three Address Code (TAC)** coupled with semantic analysis, which was further translated to **Register Transfer Language (RTL)** and generated executables for the **MIPS architecture**

## SCHOLASTIC ACHIEVEMENTS AND HONORS

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- Awarded the **Institute Academic Award twice** given to the top **10** students at IIT Bombay (2020, 2021)
- Secured **All India Rank 17** in **IIT JEE-Advanced** examination out of **245,000** candidates (2019)
- Secured **All India Rank 4** in **IIT JEE-Mains** examination out of **1.2 million** candidates (2019)
- Secured **All India Rank 10** in **KVPY**(Kishore Vaigyanik Protsahan Yojana) examination (2019)
- Secured **3 AP(Advanced Performer)** grade in courses **Calculus, Quantum Physics and Physical Chemistry**, awarded to the **top 1%** of the class for exceptional performance (2019)
- Scored **1550/1600 (among the Top 1%)** in the esteemed **SAT** conducted by Collegeboard (2018)
- Among the **top 39** students invited to attend the International **Astrophysics Olympiad (IOAA)** camp (2019)
- Ranked among the national **top 1%** selected for the **Indian National Physics Olympiad** (2019)
- Among the national **top 300** to be selected for **Olympiads** in mathematics (INMO) and **informatics** (INOI) (2019)
- Recipient of the prestigious **NTSE** scholarship awarded to the **top 1000 students** by the Government of India (2017)

## OTHER PROJECTS

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- **IITB-Proc** : Created a **16-bit multicycle processor** with synchronous write and asynchronous read operations
- **Mastermind** : Created a **Python** script using **z3** solver to play the game Mastermind against unreliable players
- **Network Simulation** : Analysed the variation of throughput with TCP variants such as Reno and Cubic and different loss probabilities using wireshark, socket programming and NS3 simulation
- **Branch predictor** : Implemented the TAGE and L-TAGE branch predictors and tested on various traces.

## TECHNICAL SKILLS

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<b>Programming</b>	C++, C, Python, MATLAB, Java, Bash scripting, SQL, VHDL
<b>Data Science</b>	Pytorch, TensorFlow, Keras, NumPy, OpenCV, Matplotlib, Scipy, Pandas
<b>Web and Others</b>	HTML, CSS, JavaScript, Flask, Django, Angular, Node.js, Git, L <sup>A</sup> T <sub>E</sub> X, Android Studio

## TEACHING AND LEADERSHIP

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**Project Lead** *Developers Community*

April 2021 - May 2022

- Worked on **ideation, planning and development** of web-based solution for student problems at IIT Bombay
- **Led** and mentored the junior developers in project implementation and building software development skills
- Contributed to the **maintenance of the InstiApp**, an information-cum-newsfeed app for IIT Bombay students

**Department Academic Mentor** *Department of Computer Science and Engineering*

May 2021 - May 2022

- Among the **26** candidates selected after extensive peer reviews and interviews out of **74** applications
- Mentored **8 CSE sophomores** and assisted them in solving academic problems faced during the academic year

**Teaching Assistant** *CS337 - Artificial Intelligence and Machine Learning*

Aug 2022 - Nov 2022

- Responsible for setting and conducting weekly lab assignments on machine learning concepts such as SVMs
- Graded theory and programming assignments, as well as answer copies of 180+ students enrolled in the course

## KEY COURSES

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**Computer Science** Data Structures and Algorithms, Design and Analysis of Algorithms, Computer Networks, Computer Architecture, Operating Systems, Automata Theory, Implementation of Programming Languages, Database and Information Systems, Cryptography and Network Security, Abstractions and Paradigms of Programming

**Data Science and ML** Data Analysis and Interpretation, Artificial Intelligence and Machine Learning, Advanced Machine Learning<sup>^</sup>, Foundations of Intelligent and Learning Agents, Advanced Reinforcement Learning, Advanced Image Processing, Medical Image Processing, Game Theory and Mechanism Design\*

\* To be completed by Winter 2022 ^ To be completed by Spring 2023

## EXTRACURRICULARS

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- Secured a **Bronze** medal in the Bosch Traffic Sign Recognition competition at the Inter-IIT Technical Meet (2021)
- Secured **1st position** in **Mathathon** organised by **Maths and Physics Club** at IIT Bombay (2019)
- Completed a two-semester course in **Swimming** offered by the **National Sports Organisation** (2019)
- Designed and created a remote-controlled bot for the **XLR8** competition at IIT Bombay (2019)
- Represented my resident hostel in the **Table Tennis General Championship at IIT Bombay** (2019)
- Scored **800/800** in three SAT subject tests - **Physics, Mathematics and Chemistry** (2019)