# Harsh Shah

Bachelor in Computer Science at Indian Institute of Technology Bombay

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# Education \_

Indian Institute of Technology Bombay, Mumbai, India Bachelor of Technology in Computer Science and Engineering Minor in Data Science and Artificial Intelligence Carnegie Mellon University, Pittsburg, PA Admitted to Masters in Machine Learning program

# Research Interests

Machine Learning, Computer Vision, Robotics, Computer Graphics

### SCHOLASTIC ACHIEVEMENTS

- Secured All India Rank 11 (top 0.01 percentile) in Joint Entrance Examination (Advance), 150K+ aspirants (2020)
- Secured All India Rank 59 (top 0.01 percentile) in Joint Entrance Examination (Mains), 1 million+ aspirants (2020)
- Secured AIR 13 in National Mathematics Talent Contest (NMTC) clearing 2 stages of nationwide exam (2018)
- Recipient of KVPY fellowship award by Govt. of India upon securing AIR 227 among 50K+ candidates (2019)
- Among Nation's top 1% in National Standard Examination in Physics (NSEP) given by 50K+ candidates (2019)
- Among Nation's top 1% in National Science Examination in Astronomy (NSEA) given by 17K+ candidates (2019)
- Awarded Advanced Performance (AP) for BB101, Biology course, in the institute 37/1300+ students (2021)

# Preprints & Submissions \_\_\_\_\_

#### Group Testing for Accurate and Efficient Range-Based Near Neighbor Search

Authors : Harsh Shah, Kashish Mittal, Ajit Rajwade

Conference (under review) : European Conference on Computer Vision (ECCV) 2024

- Devised near neighbour search algorithm for exact range-based search systems on high dimensional databases
- Optimized query time for both static and dynamic datasets, with efficient index generation and insertion time.
- Implemented novel group testing approaches to prune the search space, decreasing search time by 6 times as compared to exhaustive search, competing with other LSH, graph and inverted-index based methods

# Research Experience

#### Coherent Rendering for Mixed Reality [code] [report] [poster]

Research & Development Project | Guide : Prof. Parag Chaudhuri (IITB)

- Worked on predicting the illumination Spherical Harmonics in an environment through a reflecting sphere
- Developed a Unity-based application to coherently illuminate AR objects using the predicted spherical harmonics
- Presented a poster at the Computer Science Research Symposium, highlighting our generalized and efficient algorithm

#### Image Captioning using Cross-modal Distillation [code] [presentation]

Research & Development Project | Guide: Prof. Biplap Banerjee (IITB)

- Implemented LSTM based text encoder and ResNet image encoder to generate embeddings in joint latent space
- Used cross-modal distillation methods for aligning image representations with their semantic textual embeddings
- Trained models using PyTorch library with CUDA tools and visualized latent space embeddings using t-SNE plots

#### Nov 2020 - May 2024 CPI - 9.41/10 CPI - 9/10 Expected, Aug 2024 - Feb 2026

(Jan'23-May'23)

(Jan'-May 2022)

[paper]

# **INTERNSHIPS**

# HARMONI-Open Sourced Robot Interaction Package [LOR]

Research Intern | Guide: Prof. Hatice Gunes and Dr. Micol Spitale | AFAR lab, University of Cambridge

- Fixed major issues in a robot interaction software, HARMONI, working with multi-threaded ROS based programs
- Used Amazon Lex, Amazon Polly and local speech-to-text models for defining the behaviour of robot interaction
- Implemented behaviour trees and their unit tests, making the package modular and streamlined to use

## Natural Language to SQL Queries [code] [LOR]

Research Intern | Guide: Dr. Jian SU | Agency for Science, Technology and Research (A\*STAR)

- . Implemented LSTMs based classifier over fine-tuned BERT for improving schema encoding via cross-attention
- Merged WikiSQL and Spider datasets for extending existing text-to-SQL models over larger query set
- Trained models on remote GPU clusters using PyTorch python library and CUDA tools for accelerated training

### NIC Driver Optimization and Development [certificate]

Systems Intern | Quadeye Securities LLP

- Optimized the device drivers of ultra-low latency Network Interface Cards (NIC), for trading applications
- Utilized vectorized instructions (AVX) and speculative cache prefetching to reduce packet transmission latency
- Analysed the performance of modified linux kernel modules of the driver, using tools like perf and sockperf
- Implemented asynchronous DNS lookups, tested using a faulty local DNS server simulating delayed responses

# Key Projects

#### Intuitive Physics using LLMs | Large Laguage Models

Research Collaboration | Guide: Dr. Vibhav Vineet (Microsoft Research, Redmond)

- Analysing zero-shot as well as in-context learning capabilities of LLMs like GPT-3.5 and GPT-4, to predict motions of objects undergoing collisions and answer counterfactual questions on data extracted from videos
- Developing a restricted code execution platform to prevent execution of malicious code obtained from LLMs

#### **Reverse Image Search using Locality Sensitive Hashing** [code] | Deep Learning

Course Project | Guide: Prof. Abir De (IITB)

- Built a custom NeuralHash generator using penultimate activations of ResNet34 model trained on CalTech dataset
- Successfully employed an adversarial attack on the model via Fast Gradient Method to generate misclassified images
- Implemented Locality Sensitive Hashing (LSH) for optimizing search of images similar to an input query image

### Video Denoising using Low-rank Matrix Completion [code] [report] | Image Statistics

Course Project | Guide: Prof. Ajit Rajwade (IITB)

- . Implemented denoising algorithm using Matlab for videos corrupted with Gaussian, Poisson and spike noise
- Formulated the problem as nuclear norm minimization using singular value thresholding for matrix completion
- Extended the study to image inpainting and recommendation system using the above techniques

### **Peer-to-Peer File Transfer System** [code] | Socket Programming

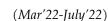
Course Project | Guide: Prof. Kameshwari Chebrolu (IITB)

- Built a local peer-to-peer file transfer system over a known network topology to search and download files
- Employed BFS algorithm to search for files till depth 2 and verified file transfer using MD5 hashing
- Used socket programming and multi-threading in C++ to establish TCP connections and build client-server model

#### C-Prototype Compiler | Language Compilation

Course Project | Guide: Prof. Amitabha Sanyal (IITB)

- Developed a compiler from scratch for a significant subset of C language (IPL-C), using Flex and Bison
- Generated Abstract Syntax Tree (AST) after lexical analysis of source program while ensuring semantic integrity
- . Implemented 32-bit x86 code generation for C programs, assuring efficient register allocation & code minimization



(*May'22-July'22*)

(May'23-July'23)

(July'23-Present)

(Sept'22-Nov'22)

(Mar'22-Apr'22)

(Mar'22-April'22)

(Jan'23-April'23)

#### Blockchains & Smart Contracts [code] [report] | Event Simulator

*Course Project* | *Guide: Prof Vinay Ribeiro (IITB)* 

- Built a **discrete-event simulator** of a P2P Crytocurrency Network, implementing **Proof Of Work** for consensus
- Implemented a Decentralised Application (DAPP) using **solidity** to simulate transactions with optimized Gas usage

#### COVID-19 Healthcare App [code] | Android Development

Course Project | Guide: Prof. Amitabha Sanyal (IITB)

- Built an android healthcare application using Java, motivated from Aarogya Setu Application for COVID-19 tracking
- Designed contact tracing system by automated exchange of bluetooth tokens when devices are in proximity

# Positions Of Responsibility \_\_\_\_\_

**Team Leader** | Mars Rover Team (IITB) | [report] [website]
 (Aug'23-Present)

 Spearheading a team with over 50+ members working in various domains like software, mechanical and biosciences, to build autonomous rover prototypes for competing in international competitions like URC (held in USA).

The team received Best Navigation Award twice in international competitions, ERC'2022 and IRC'2023

#### • Management :

- Conducted technical orientation and recruitment of new members, with a pool of more than 300 applicants
- Managing technical funds over 1.5 million INR for improving the structure and autonomy of the rover
- Collaborating with multiple firms (notably SBG Systems and Ruckus) to obtain financial and technical support

#### • Technical :

- Improved the localization of the rover by fusing data from depth sensors, GNSS and visual
- Integrated YOLOv5 algorithm for cone detection and localization for navigating the rover to guided location
- Developed a **ROS** based **android** application to fetch data from **GPS**, **accelerometer**, and **gyroscope** sensors

#### Institute Technical Convenor | Electronics & Robotics Club

• Conducted technical workshops aimed at instructing programming for robotics to over 200+ freshers

**Teaching Assistant** | Software Systems Lab | Prof. Kameshwari Chebrolu(Jan'23-April'23)

• Created challenging autograded assignments on **sed**, **awk and LATEX** for **180**+ freshers in CS department, IITB

Teaching Assistant | Foundations of Learning Agents | Prof. Shivaram Kalyanakrishnan

• Designing autograded assignments to test and apply **reinforcement learning algorithms**, for **200+** students

# Technical Skills \_\_\_\_\_

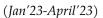
Programming Languages	C, C++, Python, Prolog, VHDL, Assembly Language (ARM), Java, Javascript
Softwares and Tools	Matlab, Git, ROS, Docker, Scilab, Flutter, Unity Game Engine, Android studio
Libraries and Packages	PyTorch, OpenGL, TensorFlow, Flax, SFML, Django, OpenCV, Scikit-Learn, Pandas

# Coursework \_

Computer Systems	Computer Networks, Data structures and algorithms, Advanced Computer Architecture,
	Design and Analysis of Algorithms, Number Theory and Cryptography
ML and Statistics	Foundations of Intelligent and Learning Agents, Information Retrieval, Learning With
	Graphs, Advanced Computer Graphics, Data Analysis and Interpretation, Mathematical
	Optimization Techniques, Advanced Image Processing
Mathematics	Discrete Structures, Linear Algebra, Differential Equations

# Extracurricular Activities

- Secured National rank 4 in Mimamsa science quiz by IISER Pune with participation of 650+ teams
- Conducted Pytorch workshop organized by AI community of Web & Coding Club for students across the university
- Received gold medal in inter hostel general championship for table tennis at IITB
- Participated in AI/ML Halliburton challenge of solving petroleum industrial problems using machine learning



(*Oct*'21-*Dec*'21)

(July'21-April'22)

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(Aug'23-Present)