

# Harsh Shah

Bachelor in Computer Science at Indian Institute of Technology Bombay

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## EDUCATION

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**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

Nov 2020 - May 2024

CPI - **9.41/10**

CPI - **9/10**

Expected, Aug 2024 - Feb 2026

## RESEARCH INTERESTS

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Machine Learning, Computer Vision, Robotics, Computer Graphics

## SCHOLASTIC ACHIEVEMENTS

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- 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 (NMTCT) 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

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

[\[paper\]](#)

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

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**Coherent Rendering for Mixed Reality** [\[code\]](#) [\[report\]](#) [\[poster\]](#)

(Jan'23-May'23)

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)

(Jan'-May 2022)

- 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

## INTERNSHIPS

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### HARMONI-Open Sourced Robot Interaction Package [LOR]

(Mar'22-July'22)

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]

(May'22-July'22)

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]

(May'23-July'23)

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

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### Intuitive Physics using LLMs | Large Language Models

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

(July'23-Present)

- 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)

(Sept'22-Nov'22)

- 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)

(Mar'22-Apr'22)

- 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)

(Mar'22-April'22)

- 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)

(Jan'23-April'23)

- 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

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

Course Project | Guide: Prof Vinay Ribeiro (IITB)

(Jan'23-April'23)

- Built a **discrete-event simulator** of a P2P Cryptocurrency 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)

(Oct'21-Dec'21)

- 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

(July'21-April'22)

- 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 Kalyan Krishnan

(Aug'23-Present)

- 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**