

Harsh Shah

Undergraduate in Computer Science at Indian Institute of Technology Bombay

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EDUCATION

Indian Institute of Technology Bombay, Mumbai, India

Nov 2020 - May 2024

Pursuing Bachelor of Technology in Computer Science and Engineering with Honors

CPI - 9.48/10

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 (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

Group Testing for Accurate and Efficient Range-Based Near Neighbor Search: An Adaptive Binary Splitting Approach

[paper]

Authors : Kashish Mittal, Harsh Shah, Ajit Rajwade

Conference (to be submitted) : European Conference on Computer Vision (ECCV) 2024

- Improved query time of range-based search systems ensuring perfect retrieval accuracy on million-scale databases
- 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

Evicting Gating Network of Mixture-Of-Experts for Domain Generalization

Authors : Harsh Shah, Vibhav Vineet, Yogesh Rawat

Conference (under review) : Conference on Computer Vision and Pattern Recognition (CVPR) 2024

- Analyzed routing in existing **mixture-of-experts** frameworks that use vision transformers for domain generalization
- Proposed **eviction of gating networks**, for uniform distribution of classification tokens among experts
- Implemented a novel **regularization** method to **calibrate** confidence of experts for generalizing over domains

RESEARCH EXPERIENCE

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]

(Jan'-May 2022)

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

INTERNSHIPS

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

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 Kalyanakrishnan

(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	Information Retrieval*, Learning With Graphs*, Advanced Computer Graphics, Data Analysis and Interpretation, Foundations of Intelligent and Learning Agents, Mathematical Optimization Techniques, Advanced Image Processing
Mathematics	Discrete Structures, Linear Algebra, Differential Equations

*To be completed by Dec' 2023

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**