Harman Singh

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Academics

- **Indian Institute of Technology Delhi (IIT-D)**
  B.Tech in Electrical Engineering; GPA: **9.349/10.0**   *July 2018 - June 2022*

Research/Work Experience

- **Meta AI,** AI Resident   July 2022 - present
  Advisor: Dr. Pengchuan Zhang, Dr. Hugo Chen, Dr. Wenhan Xiong and Dr. Qifan Wang
  - Improving Large Pre-trained Vision-Language Models in terms of compositionality and making them more object centric
  - Exploring new pre-training techniques for improved Vision-Language representation learning using external data

- **INK Lab USC,** Undergraduate Researcher   June - Jan 2021
  Advisor: Prof. Xiang Ren
  - Developed a **causal and modular**, logical reasoning architecture (**FaiRR**) [2] for **deductive reasoning** over natural language rulebases. This method is more interpretable and robust to linguistic variations, compared to previous methods
  - Compared FaiRR's logical reasoning capabilities with baseline methods based on language models like BERT, Roberta, T5, through multiple experiments, and empirically proved it to be more robust to linguistic variations

- **IBM India Research Lab,** Research Intern   July 2021 - June 2022
  Advisor: Prof. Parag Singla, DAIR Lab, IIT Delhi and Dr. Dinesh Garg, IBM Research India
  - Working on creating Neuro-Symbolic and **Object-Centric models** for multimodal (vision and language) reasoning
  - Developed a weakly supervised text-based image-editing model [1], which can be trained without ground truth output image supervision. Our model offers greater interpretability, and OOD generalization capabilities

- **LimeChat (YC'21),** NLP Engineering Intern   May - July 2021
  - Built and improved Level 3 AI chatbots for D2C brands using various technologies like PostgreSQL, Redis, Rasa etc
  - Implemented **auto-labelling** of conversations including **sentiment analysis, user intent classification etc**
  - Finetuned language models like **BERT, Rasa's DIET classifier** for obtaining text embeddings and assigning labels

- **Mangul Lab USC,** Undergraduate Bioinformatics Researcher   May 2020 - March 2021
  Advisor: Prof. Serghei Mangul   *Mangul Lab, University of Southern California*
  - Developed a novel way for Phylogenetic analysis (of spread) of Covid-19 using worldwide Covid-19 genomic data
  - Designed new algorithms for creating graphs and trees of SARS-CoV-2 genomic data, being more accurate and scalable
  - Our network representation algorithm paper has been published in **ISBRA 2021** [3]. Presented at **ABACBS 2020** and **CAME 2020** workshop (ACM-BCB 2020). Contributed to a commentary article [4] Accepted to **Nature Methods**

Publications

1. **Weakly Supervised Neuro-Symbolic Image Manipulation via Multi-Hop Complex Instructions.**
   Harman Singh, Poorva Garg, Mohit Gupta, Kevin Shah, Arnab Kumar Mondal, Dinesh Khandelwal, Parag Singla, Dinesh Garg
   Under review at ICLR-2023 [Paper]
   Accepted at Neuro Causal and Symbolic AI (nCSI) workshop at NeurIPS 2022

2. **FaiRR: Faithful and Robust Deductive Reasoning over Natural Language.**
   Soumya Sanyal and Harman Singh and Xiang Ren
   60th Annual Conference of the Association for Computational Linguistics (ACL-2022) [Paper|Code]

3. **A Novel Network Representation of SARS-CoV-2 Sequencing Data.**
   Sergey Knyazev and Daniel Novikov and Mark Grinshpon and Harman Singh and Ram Ayyala et al.
   International Symposium on Bioinformatics Research and Applications (ISBRA-2021) [Paper|Code]

4. **Unlocking capacities of viral genomics for the COVID-19 pandemic response.**
   Sergey Knyazev and Karishma Chhugani and Varuni Sarwal* and Ram Ayyala* and Harman Singh* et al.
   Nature Methods [Paper]

   *equal contribution

Skills

- **Languages**: Python, Java, C, C++, MATLAB, Verilog, LaTeX , Bash
- **ML/DL Libraries**: PyTorch(Adv), Tensorflow(Intermediate), HuggingFace(transformers), Scikit-Learn, NLTK, Spacy
- **Tools**: Git, Autodesk Inventor, Quartus, Android Studio, Arduino, Rasberry Pi

Key Projects

Deep Learning, NLP and Computer Vision

- **Faithful and Robust Deductive Reasoning over Natural Language** ⚙ 📄   June - Jan 2021
  Prof. Xiang Ren, Ink Lab, USC
  - Designed a 3 step modular architecture for interpretable and robust deductive reasoning over natural language theories containing rules + facts. Generated data for evaluating our model's robustness w.r.t ProofWriter (Tafjord et. al.)
  - Modeled the process of **rule selection, fact selection, conclusion generation** separately using 3 transformer models (RoBERTa and T5 models). This architecture's proof generation process is causal by design, and it's reasoning steps are more interpretable compared to baselines
  - Improved **average robustness** to linguistic perturbations by **2.2%**, and improved **consistency of predictions** by **3%**

- **Solving Visual Combinatorial Problems using Deep Learning** ⚙ 📄   Jan - May 2021
  Prof. Parag Singla, IIT Delhi
  - Implemented a **Visual Sudoku Solver (VSS)** to solve sudoku boards made of handwritten digits of **Arabic MNIST**
  - Used semi-supervised clustering methods like **Unsupervised Data Augmentation (UDA)**, and **InfoGAN** to classify Arabic MNIST dataset using **just 1 labeled sample** per class. Achieved **90%+** clustering accuracy using UDA
  - Implemented a **Recurrent Relational Network (RRN)** for solving a symbolic sudoku. Trained the digits classifier and RRN, end to end and obtained a VSS having **95%+** accuracy of solving an input visual sudoku board

- **Semi-Supervised Conditional GANs** ⚙   Jan - March 2021
  Self Project
  - Developed and trained the **original cGAN** with limited(∼10) labelled + unlabelled samples of MNIST, CIFAR10 etc
  - Used **KMeans** to get noisy clusters and trained the cGAN with these labels. Obtained **FID score = 49.9** on MNIST
  - Implemented **Unsupervised Data Augmentation** for clustering and a linear **label-transforming layer** (to learn from noisy labels) as an inductive bias which improved the **FID score to 45.4** using the original cGAN paper architecture

- **An Analysis of Normalizations in Deep Learning for Vision Applications** ⚙ 📄   Jan - Feb 2021
  Prof. Parag Singla, IIT Delhi
  - Implemented **Batch Norm, Instance Norm, Batch-Instance Norm, Layer Norm and Group Norm** from scratch
  - Implemented a generic **ResNet model**. Trained **ResNet-14** on **CIFAR10**, with and without the above normalizations
  - **Model with Batch-Instance Norm** gave best results for classification with **81.1% accuracy, 81.1% MacroF1 score**

- **MultiLingual Question Answering** ⚙   Nov, 2021
  Prof. Mausam, NLP Course Assignment, IIT Delhi
  - Trained a model to learn from **Hindi+Tamil QnA** data, for predicting the answer span in a given context.
  - Finetuned RoBERTa-large on Squad v2 followed by on **chaii-1+MLQA dataset**. Got **70.1%** test accuracy (class-top5)

- **Inducing Constraints in Named Entity Recognition Systems** ⚙ 📄   Feb - March 2021
  Prof Parag Singla, Deep Learning course project, IIT Delhi
  - Developed a Named Entity Recogniton (NER) system for the **GMB** dataset using a **BiLSTM** model with **Layer Norm**
  - Experimented with **random/glove word embeddings, char level embeddings**. Wrote a **CRF module** from scratch and implemented the **Viterbi algorithm**. Got **3.1%** increase in MacroF1 score compared to simple BiLSTM model

Robotics+Vision Projects

- **Four Legged Walking Robot with Vision (Minitaur)** ⚙ 📄
  Prof Sunil Jha, Prof S K Saha, IIT Delhi   *Dec 2018 - June 2019*
  - Co-Developed a 4-legged robot using 5bar mechanism for its legs.**Achieved turning, slope and step climbing**
  - Developed toe trajectories and gaiting systems for walking including diagonal gate (trotting) and wave gate
  - Integrated Vision using **OpenCV on Rasberry PiCam** for navigating and avoiding obstacles

- **Mecanum Four Wheeled Drive**
  Prof Sunil Jha, Prof S K Saha, IIT Delhi   *Dec 2018 - June 2019*
  - Developed a **4-wheeled Mecanum drive** with **distance sensors, Encoders, IMU (orientation sensors)**
  - Capable of picking and throwing blocks of dimensions approx. 30cm .30cm .30cm up to a distance of 2.2 meters
  - Capable of passing around obstacles, passing a baton, and throwing blocks , as a part of **ROBOCON 2019**

Achievements

- One of 4 undergrads from India and 27 in the world to be selected for the **AI Residency** position at **Meta AI**

- Selected for **AllenAI**'s **pre-doctoral** position and **Microsoft Research**'s **research fellow** position (declined)

- Selected for CIFAR Deep Learning Reinforcement Learning Summer School

- **IIT-Delhi Semester Merit Award** for being amongst **top 7%** students in 4 out of 8 semesters at IIT Delhi

- Secured **All India Rank 170** in IIT JEE Mains 2018 and **751** in IIT JEE Advanced amongst 1.3 million candidates

- **KVPY Scholarship** (All India Rank **160**) in 2016-17 by Department of Science and Technology Govt. of India

- Recipient of **Professor S.K Saha award** for the **best robotics team** in IIT Delhi

- Placed in **top 0.1%** students in India by **securing 100%** in Mathematics and Computer Science in class 12

Mentorship and Teaching

Research Mentorship

- **Kevin Shah** [↗] **[1]** 2021-2022
Independent study and Bachelor's thesis in CS, IIT Delhi

Teaching Assistant

- **Machine Intelligence and Learning** [↗] Aug - Dec 2021
Instructors: Prof Sumeet Agarwal and Prof Jayadeva

  Responsible for conducting problem solving and programming (python/pytorch) tutorials, grading assignments, taking vivas for projects and course assignments, creating assignment questions.

- **Introduction to Electrical Engineering** Nov - March 2021
Instructors: Prof Anuj Dhawan

  Responsible for conducting problem solving tutorials, creating exam questions and grading exam copies

Relevant Coursework

Machine Learning, Deep Learning(Special Topics in Machine Learning), Meta Learning(Special Module in Machine Learning), Markov Decision Process and Reinforcement Learning, Probability and Stochastic Processes, Linguistics(Language Science), Natural Language Processing, NLP Seminar (Special Module in AI), Data Structures and Algorithms, Analysis and Design of Algorithms, Linear Algebra and Differential Equations, Calculus, Signals and Systems
Online: Stanford CS229-Machine Learning, CS231-Convolution Neural Networks for Visual Recognition, Deep Learning and Neural Networks

References

- **Prof. Xiang Ren, University of Southern California**

- **Dr. Hugo Chen, Research Scientist, Meta AI**

- **Prof. Parag Singla, IIT Delhi**

- **Prof. Dinesh Garg, IBM Research India**

- **Prof. Serghei Mangul, University of Southern California**