Neeraj Varshney

Ph.D. Candidate (5^{th} Year)
Computer Science (NLP/NLU)
Arizona State University

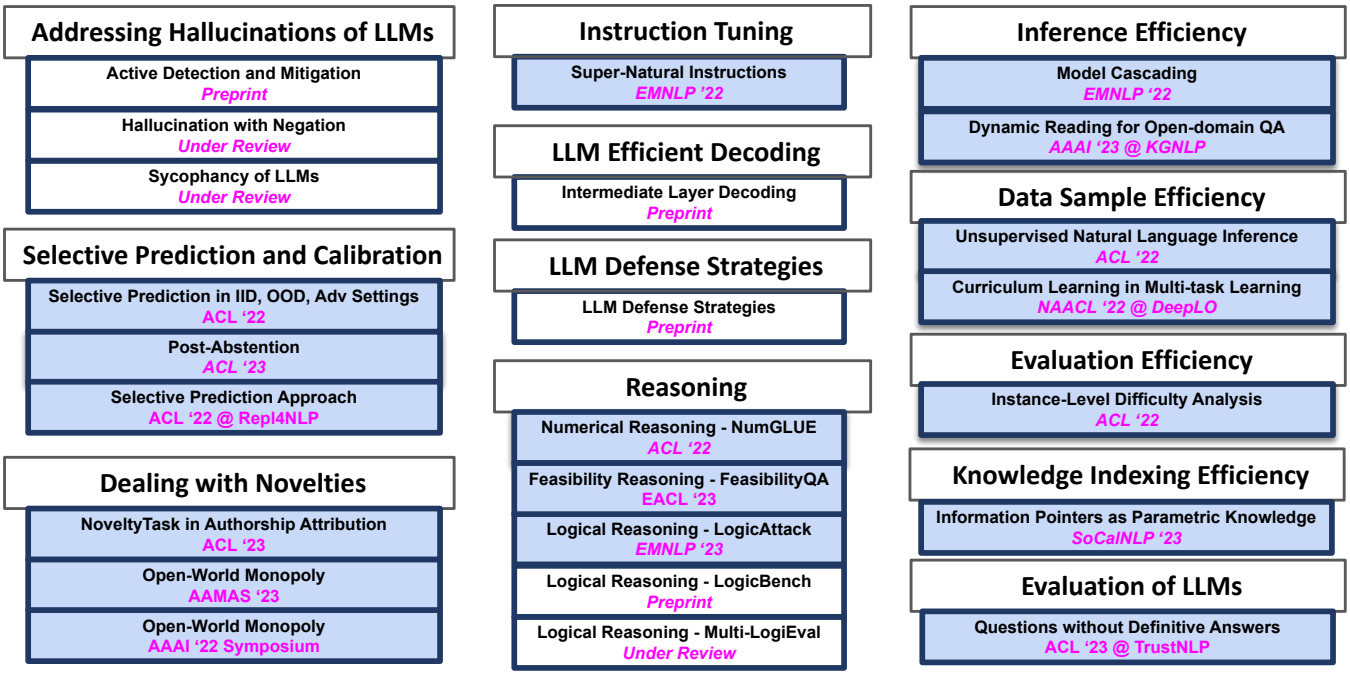
Email: nvarshn2@asu.edu
Website: nrjvarshney.github.io
Semantic Scholar: Neeraj-Varshney
LinkedIn: neerajvarshney97

Research Statement

My research mission is to develop Reliable and Efficient Natural Language Processing / Understanding systems.

Specifically, I focus on problems such as Mitigating the Hallucinations of LLMs, Efficient LLM Decoding, Instruction Tuning, Question Answering, Inference Efficiency, Text Generation, LLM Defense Strategies, Selective Prediction, Training Sample Efficiency, Large Language Models, and Retrieval Augmented Inference.

My Research Work



Publication Venues: **ACL** ('22 & '23), **EMNLP** ('22 & '23), **EACL** ('23), **NAACL** ('22), **AAAI** ('22 & '23), **AAMAS** ('23)
Thesis Committee: Dr. Chitta Baral (Chair) Dr. Yezhou Yang Dr. Nakul Gopalan Dr. Pratyay Banerjee

Technical Skills

Languages : Python, Java, C, C++
Libraries & Tools : PyTorch, PyTorch-lightning, Huggingface Transformers, Spacy, OpenAI, Pyserini, NumPy, Matplotlib, Pandas, NLTK, Word2vec, Git, Linux, Amazon Mechanical Turk, PyCharm, Jupyter, Colab, MS Office

Selected Projects

1. Detecting and Mitigating Hallucinations of LLMs by Validating Low-Confidence Generation Preprint, 2023
Neeraj Varshney, Wenlin Yao, Hongming Zhang, Jianshu Chen, Dong Yu

- Addressing the critical problem pertaining to hallucinations of LLMs, we developed an approach that actively detects and mitigates hallucinations during the generation process.
- In our approach, we first identify the candidates of potential hallucination leveraging the model's logit output values, check their correctness through a validation procedure, mitigate the detected hallucinations via prompting, and then continue generating the subsequent sentences.
- Showed the effectiveness of our approach in mitigating hallucinations of models such as GPT-3.5 and Vicuna in multiple tasks, such as article generation, multi-hop QA, and false premise QA.

2. Accelerating LLM Inference by Enabling Intermediate Layer Decoding Preprint, 2023
Neeraj Varshney, Agneet Chatterjee, Mihir Parmar, Chitta Baral

- We instruction tuned LLMs with additional explicit **L**osses from the **I**n**T**ermediate lay**E**rs (LITE) and show that it enables these layers to acquire 'good' generation ability without affecting the generation ability of the final layer.
- We performed '*dynamic confidence-based early exiting*' at token level from the intermediate layers which improves the efficiency of inference while maintaining the generation quality.
- Through comprehensive experiments by instruction tuning LLaMA-2 models on the Alpaca dataset and evaluating on Vicuna, WizardLM, Koala, and Self-Instruct, we show that dynamic early exiting achieves consistent and considerable cost improvements (37.86% for 7B and 46.35% for 13B mode) while maintaining the generation quality.

3. Post-Abstention: Towards Reliably Re-Attempting the Abstained Instances in QA ACL, 2023 (Oral)

Neeraj Varshney, Chitta Baral

- Developed Post-Abstention methods such as Re-Examining the top-N Predictions (REToP) and an ensembling-based technique that aim at re-attempting to answer the abstained instances of a given selective prediction system with the objective of increasing its 'coverage' without significantly sacrificing its 'accuracy'.
- Showed that state-of-the-art models, even when they are wrong, are often able to rank the ground truth answer as one of their top-N predictions. Building up on this, we developed an auxiliary model that re-examines the top-N predictions of the model to find the correct answer.
- Showed that our approach successfully reduces the risk of the system in both in-domain and out-of-domain settings.

4. Dynamic Reading Approach for Efficiently Utilizing External Knowledge in Open-domain QA AAAI @ KGNLP 2023

Neeraj Varshney, Man Luo, Chitta Baral

- Developed an approach that dynamically reads the external knowledge in multiple 'knowledge iterations' instead of using a large fixed number of passages for answering open-domain questions.
- Our approach utilizes both the 'closed-book' (parametric knowledge) and the 'open-book' (external knowledge) inferences in an efficient manner to answer an open-domain question.
- Comparing with the state-of-the-art Fusion-in-Decoder (FiD) reader, our approach matches FiD's accuracy by utilizing just 18.32% of its reader inference cost (FLOPs) and also outperforms it by achieving up to 55.10% and 77.32% accuracy on NQ Open and TriviaQA respectively.

5. Model Cascading: Towards Jointly Improving Inference Efficiency and Accuracy of NLP Systems EMNLP, 2022

Neeraj Varshney, Chitta Baral

- Developed a cascading technique that utilizes a collection of models of varying capacities to accurately yet efficiently output predictions.
- Our methods leverage MaxProb and Distance-to-Uniform values to decide when the prediction with low-cost models is sufficient and when bigger (and relatively higher cost) models are required.

6. Investigating Selective Prediction Approaches Across Several Tasks in IID, OOD, and Adv. Settings ACL, 2022

Neeraj Varshney, Swaroop Mishra, Chitta Baral

- Selective Prediction enables the models to abstain from answering when their prediction is likely to be incorrect; thus improving their reliability. We systematically studied 'selective prediction' approaches in a large-scale setup of 17 datasets across NLI, QA, and Duplicate Detection tasks under in-domain, out-of-domain, and adversarial settings.
- Demonstrated that despite leveraging additional resources (such as held-out data or computation), none of the existing approaches consistently and considerably outperforms the simple *MaxProb* baseline. Also analyzed approaches on their task-transfer ability.

7. ILDAE: Instance-Level Difficulty Analysis of Evaluation Data ACL, 2022

Neeraj Varshney, Swaroop Mishra, Chitta Baral

- Developed a method to compute instance-level difficulty score for evaluation instances and demonstrated their five novel applications such as:
  - Conducting efficient-yet-accurate evaluations with fewer instances saving computational cost and time,
  - Improving the quality of existing evaluation datasets by repairing erroneous and trivial instances,
  - Indicating Out-of-Domain performance more reliably.

8. Unsupervised Natural Language Inference Using PHL Triplet Generation ACL, 2022

Neeraj Varshney, Pratyay Banerjee, Tejas Gokhale, Chitta Baral

- Designed three novel unsupervised settings for NLI and proposed a procedural data generation approach that outperforms existing approaches by $\sim$13% and raises the SOTA unsupervised performance to 66.75%.
- Also developed a general model-in-the-loop adversarial data collection strategy to efficiently collect high-quality non-trivial data instances that help achieve 12.2% higher accuracy with as little as $\sim 0.1\%$ of the training dataset.

9. Instruction Tuning and Benchmarking Generalization on 1,600+ Language Tasks EMNLP, 2022

Yizhong Wang, ..., Neeraj Varshney, ..., Yejin Choi, Hannaneh Hajishirzi, Noah A. Smith, Daniel Khashabi

- Developed Tk-INSTRUCT, a transformer model trained to follow a variety of in-context instructions (plain language task definitions or k-shot examples).
- Introduced Super-Natural Instructions, a benchmark of 1,616 diverse NLP tasks and their expert-written instructions.
- Showed that Tk-INSTRUCT outperforms existing instruction-following models such as InstructGPT by over 9% on our benchmark despite being an order of magnitude smaller.

10. NumGLUE: A Suite of Mathematical Reasoning Tasks in NLP ACL, 2022 (Oral)

Swaroop Mishra, Arindam Mitra, Neeraj Varshney, Bhavdeep Sachdeva, Peter Clark, Chitta Baral, Ashwin Kalyan

- Developed a knowledge-retrieval based multi-task learning method that outperforms existing models.
- Built a multi-task benchmark that evaluates NLP systems on eight different numerical understanding tasks and evaluated the efficacy of neural models including large language models.

11. On Efficiently Indexing External Knowledge for Knowledge Intensive Language Tasks Under Review, 2023

- Bypassing the requirement of storing vector embeddings of passages of a knowledge corpus and computing a similarity score with query embedding for retrieving relevant knowledge, we developed an approach to index the passages of the corpus in the parameters of a Language Model.
- Trained a generative model to take a query as input and generate identifiers of the passages (from the corpus) that are relevant to the query. Our identifiers also encode the semantic meaning of the passages.

12. LogicAttack: Adversarial Attacks for Evaluating Logical Consistency of Natural Language Inference EMNLP, 2023

Mutsumi Nakamura, Santosh Mashetty, Mihir Parmar, Neeraj Varshney, Chitta Baral

13. Towards Improving Selective Prediction Ability of NLP Systems ACL @ RepL4NLP, 2022

Neeraj Varshney, Swaroop Mishra, Chitta Baral

- To improve the selective prediction performance (and hence the reliability) of a system, we developed a method that calibrates the model outputs using prediction confidence and difficulty level of the instances.
- Instantiated the proposed method in NLI and Duplicate Detection tasks and showed that it outperforms existing approaches and achieves up to 15% improvement over the MaxProb baseline.

14. A Unified Evaluation Framework for Novelty Detection and Accommodation in NLP ACL, 2023

Neeraj Varshney, Himanshu Gupta, Eric Robertson, Bing Liu, Chitta Baral

15. On Dealing with Questions that Don't have Definitive Answers ACL @ TrustNLP, 2023

Neeraj Varshney, Ayushi Agarwal*, Nisarg Patel*, Mihir Parmar, ..., and Chitta Baral*

16. On Evaluating NLP Models' Understanding of Feasibility EACL, 2023

Himanshu Gupta, Neeraj Varshney, Swaroop Mishra, kuntal Pal, S. Sawant, K. Scaria, S. Goyal, Chitta Baral

17. Designing a Learning Curriculum for Developing a Multitask Model NAACL @ DeepLo, 2022

Neeraj Varshney, Swaroop Mishra, Chitta Baral

- Developed dataset and instance-level techniques to arrange training instances into a learning curriculum based on the model's own interpretation of difficulty.
- Achieved 4% accuracy improvement over other methods on experiments conducted for 12 datasets covering a variety of language understanding tasks.

18. Evaluation and Analysis of LLM Defense Strategies on Safety and Over-Defensiveness Preprint, 2023

Neeraj Varshney, Pavel Dolin, Agastya Seth, Chitta Baral

19. A Benchmark for Analyzing Logical Reasoning Capabilities of Language Models Preprint, 2023

Man Luo, ..., Neeraj Varshney, ..., Somak Aditya, Chitta Baral

20. Can NLP Models Correctly Reason Over Contexts that Break the Common Assumptions? Preprint, 2023

Neeraj Varshney, Mihir Parmar, ... , Chitta Baral

21. Methods and Mechanisms for Interactive Novelty Handling in Adversarial Environments AAMAS 2023 (E)

Tung Thai, M. Shen, ..., Neeraj Varshney, Chitta Baral, Subbarao Kambhampati, Jivko Sinapov, Matthias Scheutz

Experience

Tencent AI — May 2023 – Aug 2023
NLP Research Intern — *Bellevue, Washington*

- Developed an approach for Detecting and Mitigating Hallucinations of Large Language Models.

Amazon Science — May 2022 – Aug 2022
Applied Scientist Intern, Alexa AI — *Seattle, Washington*

- Web Question-Answering system using Information Retrieval.

Microsoft — July 2018 – Aug 2019
Software Developer — *Bangalore, India*

- An ML driven chat recommendation system aimed at augmenting user engagement with Microsoft 'Teams'.

Samsung R&D Institute — Summer 2017
Research Intern — *Bangalore, India*

- Developed a 'context prediction' application leveraging event features such as app usage, location, and sensor data.

Education

Arizona State University — Tempe, AZ, USA
Ph.D. in Computer Science — *Fall 2019 – Spring 2024 (Expected)*

- **Advisor**: Dr. Chitta Baral
- **CGPA**: 4/4
- **Awards**: SCAI doctoral fellowship (2 times), GPSA Outstanding Research Award, Outstanding Reviewer from EACL 2023, GPSA awards (3 times), SCAI conference travel award (2 times), Graduate College awards (5 times), AAAI student scholarship, ACL registration award.
- **Internships**: Amazon Science (Summer 2022), Tencent AI (Summer 2023)

BITS Pilani, Pilani Campus, India — Pilani, India
B.E (Hons) Computer Science — *2014-2018*

- **CGPA**: 9.11/10 (with Distinction)
- **Experience**: 'Web Intelligence & Social Computing' research lab under Prof. Poonam Goyal, CEERI research lab under Dr. J.L. Raheja.
- **Internships**: Microsoft, Samsung R&D Institute, Valuefirst Digital Media.

Honors and Awards

- **Outstanding Reviewer** for EACL'23 (Question Answering track).
- **Outstanding Research Award**, GPSA ASU, 2023
- SCAI **Doctoral Fellowship**, ASU, 2023.
- ASU **Jumpstart Research Grant**, 2023 and 2024.
- Selected for **AAAI Student Scholarship**, 2023.
- **Graduate College Award**, ASU for AAAI 2023, ACL 2022, NAACL 2022, EMNLP 2022, and ACL 2023.
- **GPSA Award**, ASU for EMNLP 2022 and ACL 2022.
- SCAI **Conference Award**, ASU for EMNLP and ACL '22.
- Registration award from Repl4NLP for ACL, 2022.
- GPSA Internship Travel Award, ASU 2023.

Service

- Reviewer for **ACL**, **EMNLP**, **EACL** (Outstanding Reviewer), **CVPR workshop** (Open-Domain Retrieval Under a Multi-Modal Setting)
- Reviewer for GPSA **Research Grants**, ASU.
- 20+ ML/NLP **Medium Articles** with **100K+ views**
- Mentored B.S and M.S students for course projects and co-authored multiple research papers with them.
- Served as Maths teacher for underprivileged kids through **National Service Scheme (NSS)**, India.
- Participated in blood donation camps and health awareness drives.

Courses

Natural Language Processing
Knowledge Representation
Statistical Machine Learning
Data Mining
Artificial Intelligence
Social Media Mining
NLP Methods in BioMedical
Mobile Computing

Collaborators

- **Dong Yu** (Distinguished Scientist at Tencent AI)
- **Swaroop Mishra** (Research Scientist at Google Brain)
- **Tejas Gokhale** (Assistant Prof. at Univ. of Maryland, BC)
- **Arindam Mitra** (Research Scientist at Microsoft Research)
- **Bing Liu** (Professor at University of Illinois at Chicago)
- **Daniel Khashabi** (Assistant Prof. at Johns Hopkins Univ.)
- **Pratyay Banerjee** (Applied Scientist at Alexa AI, Amazon)
- **Kuntal Pal** (AI ML Senior Associate at JPMorgan Chase & Co.)
- **Jianshu Chen** (Principal Researcher at Tencent AI)
- **Hongming Zhang** (Senior Research Scientist at Tencent AI)
- **Wenlin Yao** (Senior Research Scientist at Tencent AI)
- **Ashwin Kalyan** (Allen AI)
- **Yizhong Wang** (Allen AI, University of Washington)
- **Rik Koncel-Kedziorski** (Alexa AI)
- **Eric Robertson** (PAR Government)
- **Man Luo** (Research Fellow at Mayo Clinic)
- **Mihir Parmar** (ASU)