Zhihong Shao

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Research Interests

My interests are in natural language processing and deep learning. I am particularly interested in how we can build a robust and scalable AI system that can leverage diverse skills (e.g., tool use and reasoning) to aggregate possibly-heterogeneous information and answer natural language questions precisely regardless of their complexity.

Education

Tsinghua University, Beijing, China — September 2019 - Present
Ph.D. Student, Computer Science and Technology
Advisor: Minlie Huang

Beihang University, Beijing, China — September 2015 July 2019
B.E., Computer Science and Technology
GPA: 3.86/4, *Rank:* 2/213

Research Highlights

LLM Multi-Step Reasong & Tool Augmentation

- `Improve Math Reasoning with Tool Integration`: ToRA [3] (ToRA-34B is the first open-source TOOL-AUGMENTED LLM scoring over 50% on the competition-level MATH dataset, with 800+ github stars);
- `Improve Math Reasoning via Math Training and RL`: (i) Process-based Reward Model: Math-Shepherd [1] for process supervision without human annotations; (ii) Math Training and RL: DeepSeekMath [15] (DeepSeekMath 7B is the first open-source LLM scoring over 50% WITHOUT RELYING ON TOOLS on the competition-level MATH dataset, close to GPT-4 and Gemini Ultra, with 700+ github stars);
- `Improve Formal Math Reasoning with Synthetic Data`: DeepSeek-Prover [13] trained on formal math data synthesized by iterating auto-formalization and proof search, which solves 50% of problems from miniF2F-test;
- `Inference-Time Optimization`: (i) Prompt Optimization: Synthetic Prompting [6] for automatically synthesizing high-quality CoT demonstrations for self-improvement; (ii) Self-Correction based on Feedback from Tools: CRITIC [5] which shows that current LLMs struggle with intrinsic self-correction and propose tool-aided correction for more stable improvements.

Publications

[1] Math-Shepherd: Verify and Reinforce LLMs Step-by-step without Human Annotations
Peiyi Wang, Lei Li, **Zhihong Shao**, R.X. Xu, Damai Dai, Yifei Li, Deli Chen, Y.Wu, Zhifang Sui
Annual Meeting of the Association for Computational Linguistics (ACL), 2024.

[2] Learning Task Decomposition to Assist Humans in Competitive Programming
Jiaxin Wen, Ruiqi Zhong, Pei Ke, **Zhihong Shao**, Hongning Wang, Minlie Huang
Annual Meeting of the Association for Computational Linguistics (ACL), 2024.

[3] ToRA: A Tool-Integrated Reasoning Agent for Mathematical Problem Solving
Zhihong Shao*, Zhibin Gou*, Yeyun Gong, Yelong Shen, Yujiu Yang, Minlie Huang, Nan Duan, Weizhu Chen
International Conference on Learning Representations (ICLR), 2024.

[4] Enhancing Retrieval-Augmented Large Language Models with Iterative Retrieval-Generation Synergy

Zhihong Shao, Yeyun Gong, Yelong Shen, Minlie Huang, Nan Duan, Weizhu Chen
Findings of Empirical Methods in Natural Language Processing (Findings of EMNLP), 2023.

[5] CRITIC: Large Language Models Can Self-Correct with Tool-Interactive Critiquing
Zhibin Gou, **Zhihong Shao**, Yeyun Gong, Yelong Shen, Yujiu Yang, Nan Duan, Weizhu Chen
International Conference on Learning Representations (ICLR), 2024.

[6] Synthetic Prompting: Generating Chain-of-Thought Demonstrations for Large Language Models
Zhihong Shao, Yeyun Gong, Yelong Shen, Minlie Huang, Nan Duan, and Weizhu Chen
International Conference on Machine Learning (ICML), 2023.

[7] Chaining Simultaneous Thoughts for Numerical Reasoning
Zhihong Shao, Fei Huang, and Minlie Huang
Findings of Empirical Methods in Natural Language Processing (Findings of EMNLP), 2022.

[8] Answering Open-Domain Multi-Answer Questions via a Recall-then-Verify Framework
Zhihong Shao, and Minlie Huang
Annual Meeting of the Association for Computational Linguistics (ACL), 2022.
(Best QA system on the AmbigNQ leaderboard)

[9] AdvExpander: Generating Natural Language Adversarial Examples by Expanding Text
Zhihong Shao, Zhongqin Wu, and Minlie Huang
IEEE/ACM Transactions on Audio, Speech, and Language Processing (TASLP), vol. 30, pp. 1184-1196, 2022.

[10] A Mutual Information Maximization Approach for the Spurious Solution Problem in Weakly Supervised Question Answering
Zhihong Shao, Lifeng Shang, Qun Liu, and Minlie Huang
Annual Meeting of the Association for Computational Linguistics (ACL), 2021.

[11] Long and Diverse Text Generation with Planning-based Hierarchical Variational Model
Zhihong Shao, Minlie Huang, Jiangtao Wen, Wenfei Xu, and Xiaoyan Zhu
Empirical Methods in Natural Language Processing (EMNLP), 2019.

Preprint

[12] DeepSeek-Coder-V2: Breaking the Barrier of Closed-Source Models in Code Intelligence
Qihao Zhu*, Daya Guo*, **Zhihong Shao***, Dejian Yang*, DeepSeek-AI
Arxiv abs/2406.11931, 2024.

[13] DeepSeek-Prover: Advancing Theorem Proving in LLMs through Large-Scale Synthetic Data
Huajian Xin, Daya Guo, **Zhihong Shao**, Zhizhou Ren, Qihao Zhu, Bo Liu, Chong Ruan, Wenda Li, Xiaodan Liang
Arxiv abs/2405.14333, 2024.

[14] DeepSeek-V2: A Strong, Economical, and Efficient Mixture-of-Experts Language Model
DeepSeek-AI
Arxiv abs/2405.04434, 2024.

[15] DeepSeekMath: Pushing the Limits of Mathematical Reasoning in Open Language Models
Zhihong Shao, Peiyi Wang, Qihao Zhu, Runxin Xu, Junxiao Song, Mingchuan Zhang,

Y.K. Li, Y. Wu, Daya Guo
Arxiv abs/2402.03300, 2024.

[16] DeepSeek LLM: Scaling Open-Source Language Models with Longtermism
DeepSeek-AI
Arxiv abs/2401.02954, 2024.

[17] CoTK: An Open-Source Toolkit for Fast Development and Fair Evaluation of Text Generation
Fei Huang, Dazhen Wan, **Zhihong Shao**, Pei Ke, Jian Guan, Yilin Niu, Xiaoyan Zhu, and Minlie Huang
Arxiv abs/2002.00583, 2020.

Awards

Lenovo Scholarship, Tsinghua University 2023
1st Prize, Comprehensive Scholarship, Tsinghua University 2022
2nd Prize, Comprehensive Scholarship, Tsinghua University 2021
3rd Prize, the National Final of "LAN QIAO CUP" C/C++ Group 2018
1st Prize, National College Students Mathematics Competition (non-math-major) 2016
China National Scholarship 2016, 2017, 2018

Services

Reviewer/Program Committee: ACL, EMNLP, NLPCC, ARR

Teaching Assistant

Artificial Neural Network Fall 2019 - 2022
Instructor: Minlie Huang

Object-Oriented Programming Spring 2020 - 2023
Instructor: Minlie Huang
Also gave guest lectures and made assignments