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

Tool-Augmented Large Language Models

- `Optimize LLM-Tool Interaction and Adapt Tools for LLMs based on the Interaction Data`: ITER-RETGEN [2] with generation-augmented retrieval and generation-augmented retrieval adaptation;
- `Train LLMs to Integrate Tool Use into Generation`: ToRA [1] (ToRA-34B is the first open-source LLM scoring over 50% on the competition-level MATH dataset, close to GPT-4 solving problems with code, with 740+ github stars);
- `Inference-Time Optimization`: (i) Prompt Optimization: Synthetic Prompting [4] for automatically synthesizing high-quality CoT demonstrations; (ii) Self-Correction based on Feedback from Tools: CRITIC [3] (Basically the first paper to show that current LLMs struggle with intrinsic self-correction and propose tool-aided correction for more stable improvements).

PUBLICATIONS

[1] 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.

[2] 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.

[3] 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.

[4] 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.

[5] 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.

[6] 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)

[7] 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.

[8] 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.

[9] 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

[10] Math-Shepherd: A Label-Free Step-by-Step Verifier for LLMs in Mathematical Reasoning
Peiyi Wang, Lei Li, **Zhihong Shao**, R.X. Xu, Damai Dai, Yifei Li, Deli Chen, Y.Wu, Zhifang Sui
Arxiv abs/2312.08935, 2023.

[11] 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.

RESEARCH EXPERIENCE

Microsoft Research Asia   Sep 2022 - Nov 2023, Beijing, China
Research Intern (Supervisors: Yeyun Gong, Nan Duan, Yelong Shen, Weizhu Chen)
- [Knowledge-Grounded Generation]: ITER-RETGEN [2], which synergizes retrieval and generation iteratively, is a strong method that enables large language models to leverage intrinsic and extrinsic knowledge flexibly;
- [Tool-Augmented Reasoning]: (i) **Synthetic Prompting** [4] elicits better reasoning in large language models with model-synthesized chain-of-thought demonstrations, achieving a new state-of-the-art on numerical reasoning, symbolic reasoning, and algorithmic reasoning tasks; (ii) **ToRA** [1] integrates natural language reasoning with program-based tool use for mathematical reasoning; ToRA-34B is the first open-source model to attain an accuracy over 50% on the competition-level MATH dataset; (iii) **CRITIC** [3] teaches large language models to correct themselves via interactions with tools.

CoAI Lab, Tsinghua University   Sep 2019 - Present, Beijing, China
Ph.D. Student (Supervisor: Minlie Huang)
- [Knowledge-Grounded Generation]: **RECTIFY** [6], a Recall-then-Verify framework that exploits retrieved knowledge comprehensively, tops AmbigNQ;

- [Tool-Augmented Reasoning]: (i) **CANTOR** [5], the first non-autoregressive numerical reasoner, outperforms $174\times$ larger PaLM 62B on grade school math; (ii) **MIMAX** [8], a weakly-supervised training algorithm that is applicable to various neuro-symbolic reasoning models;

- [Robust Natural Language Understanding]: **AdvExpander** [7], a novel insertion based textual adversarial attack, reveals new robustness issues.

- [Text Generation and Evaluation]: (i) **PHVM** [9], a data-to-text generation model; (ii) **CoTK** [11], a toolkit for fair evaluation.

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