LAI, ZHEJIAN

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EDUCATION

NANJING UNIVERSITY | Natural Language Processing Group　　　　　　　　　　　2023.09 - Present
- ✓ Master of Science in Computer Science and Technology (Expected)
- ✓ Concentrations: Synthetic Data & Reasoning LLMs & Multilingual LLMs
  - ✧ First Prize Academic Scholarship (Top 5%) for AY 2023-2024

DALIAN UNIVERSITY OF TECHNOLOGY　　　　　　　　　　　　　　　　　　　　2019.09 - 2023.06
- ✓ Bachelor of Engineering in Network Engineering
- ✓ GPA: 4.27/5 (Ranking: 2/119)
  - ✧ National Scholarship (Top 0.8%) for AY 2020-2021 & 2021-2022
  - ✧ Huawei Intelligent Base Student Scholarship (Top 1%) for AY 2022-2023

RESEARCH EXPERIENCE

MAKING MATHEMATICAL REASONING ADAPTIVE　　　　　　　　　　　　　　　2025.03 - 2025.09

Research content:
- ✓ Attributed failures in robustness and generalization in LLM mathematical reasoning to "spurious reasoning", wherein answers are derived from superficial features. In contrast, we encourage an "adaptive reasoning" paradigm in which the LLM understand and solve query by logic while be adaptive to varying variable values.
- ✓ Proposed AdaR to enable LLMs "adaptive reasoning": after extracting query template and its corresponding problem-solving code, it synthesizes logically equivalent queries by altering variable values and obtains reliable answers through code execution, and finally generates question-answer pairs following a sanity check. Combined with RLVR, the synthetic data provided reliable rewards to penalize spurious reasoning and encourage adaptive reasoning.
- ✓ Indicated that under small amount of data, AdaR significantly improves robustness and generalization. Analysis demonstrates that AdaR enables LLMs to acquire algebraic reasoning, exhibiting scalability and broad applicability.

Main contributions:
- ✓ Spearheaded designing AdaR framework's overall research plan, including the correspondence between query template and problem-solving code, controllable perturbation, sanity check, and combing synthetic data with RLVR; implemented the entire pipeline independently.
- ✓ Designed most analysis experiments and completed all experimental work independently.

Paper status: Submitted to ICLR 2026 as the co-first author. https://arxiv.org/abs/2510.04617

HOW DOES MULTILINGUAL ALIGNMENT ENHANCE LLMS' MULTILINGUAL CAPABILITIES?

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Research content:
- ✓ Proposed a new finer-grained neuron identification algorithm, detecting language neurons (including language-specific neurons and language-related neurons) and language-agnostic neurons.
- ✓ Divided LLMs' internal process for multilingual inference into four parts: (1) multilingual understanding, (2) shared semantic space reasoning, (3) multilingual output space transformation, and (4) vocabulary space output based on distributional characteristics of different types of neurons.
- ✓ Systematically analyzed the models before and after alignment with a focus on different types of neurons and also examined the phenomenon of "Spontaneous Multilingual Alignment."

Main contributions:
- ✓ Implemented alignments of all models, and proposed a conjecture for a 4-stage model inference process.
- ✓ Improved language neuron detection algorithm and designed part of the neuron statistics-related experiments.

Paper status: Submitted to AAAI 2026 as the co-first author. https://arxiv.org/abs/2505.21505

ALLEVIATING DISTRIBUTION SHIFT IN SYNTHETIC DATA FOR MACHINE TRANSLATION QUALITY ESTIMATION 2023.12 - 2025.02

Research content:

✓ Proposed a novel framework for alleviating distribution shift in synthetic quality estimation data by fully utilizing the available supervised signals and increasing diversity of models.

✓ Verified the best performance of the method in both supervised and unsupervised scenarios, and outperformed the mainstream strong baseline models such as CometKiwi and GPT-4 with a lighter model size.

✓ Conducted further analysis to offer insights into synthetic data generation that could benefit reward models for other tasks.

Main contributions:

✓ Proposed and implemented a dual-model synthetic data framework with Annotator and Generator.

✓ Innovated a label aggregation method based on syntactic dependency tree and lowest common ancestor algorithm to realize the alignment of labeling results with human preferences.

✓ Designed and conducted ablation experiments and in-depth analytical experiments.

✓ Implemented all experiment code independently.

Paper status: Published in *Proceedings of the 63rd Annual Meeting of the Association for Computational Linguistics* (Pages 7546–7560) as the co-first author. https://aclanthology.org/2025.acl-long.373

WHY NOT TRANSFORM CHAT LARGE LANGUAGE MODELS TO NON-ENGLISH? 2024.07 - 2025.02

Research content:

✓ Put forward a framework to migrate the ChatLLM model from English to non-English environments.

✓ Verified that this framework promotes the simultaneous enhancement of the LLM's non-English language performance with English language performance, in which both the security and effectiveness that RLHF brings to the model are migrated.

✓ Introduced the Recover Knowledge Distillation (RKD) technique in the framework which successfully mitigated the catastrophic forgetting problem during language migration.

Main contributions: Validated the effectiveness of the prototype (Translation CoT + RKD) initially and participated in coding for the analytical experimental content.

Paper status: Accepted by FCS as the fourth author. https://doi.org/10.48550/arXiv.2405.13923

UNIFY WORD-LEVEL AND SPAN-LEVEL TASKS: NJUNLP'S PARTICIPATION FOR THE WMT2023 QUALITY ESTIMATION SHARED TASK 2023.07 - 2023.11

Research content:

✧ Developed an efficient and interpretable pseudo-data augmentation approach tailored for machine translation quality evaluation, utilizing rule-based perturbations on reference sentences within parallel corpora.

✧ Simulated errors based on observed distributions of error lengths, locations, and severities identified in the validation dataset to generate interpretable pseudo-data.

✧ Obtained final model through a two-stage training strategy of pre-training + multi-task fine-tuning.

Main contributions:

✧ Designed a rule-based pseudo-data augmentation approach.

✧ Independently coded pseudo-data generation and model pre-training, and completed corresponding experiments.

Paper status: Published in *Proceedings of the Eighth Conference on Machine Translation* (pages 829–834, https://arxiv.org/pdf/2309.13230) and won all 3 tasks in En-De direction in WMT2023 Quality Estimation, namely word-level MQM, sentence-level MQM, and error span detection.

IMPROVED PSEUDO DATA FOR MACHINE TRANSLATION QUALITY ESTIMATION WITH CONSTRAINED BEAM SEARCH   2022.06 - 2023.06

Research content:

✧ Proposed a pseudo-data augmentation approach based on constrained beam search, which guided the pseudo-translation generation by the generation probability of references, to significantly reduce the risk of the TER tool marking samples with high false-positive rate, and thus effectively alleviated the problem of the scarcity of HTER data in the field of machine translation quality estimation.

✧ Verified to significantly improve the model performance in supervised and unsupervised scenarios.

Main Contributions:

✧ Completed main experimental test, and reproduction and performance evaluation of related mainstream comparative methods, and coded for all experimental contents.

✧ Undertook quantitative and qualitative experiments to test effectiveness of the proposed constrained beam search algorithm, and comprehensive ablation experiments to explore the impact of key hyperparameters and generative probability adjustment function on the overall performance improvement of the algorithm.

Paper status: Published in *Proceedings of the 2023 Conference on Empirical Methods in Natural Language Processing* (Pages 12434-12447) as the second author. https://aclanthology.org/2023.emnlp-main.764.pdf

CONTESTS AND AWARDS

First Place of WMT2023 Quality Estimation Shared Tasks in En-De	2023
National Individual 2nd Prize of China Collegiate Computing Contest	2021
Silver Medal of 2nd China Collegiate Algorithm Design & Programming Challenge Contest (Autumn Competition)	2020
Second Place of 12th Chinese Mathematics Competition for College Students (Non-mathematical Background)	2020
Golden Medal of 1st Liaoning Province Collegiate Programming Contest	2020