Chenrui Duan

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Research Interests: Large Language Model Applications, Multimodal Models, Autoregressive Generative Models

Education

Ph.D. in Computer Science and Technology **Zhejiang University (C9)** **Hangzhou** *09/2020 - present*
Advisor: Prof. Stan Z.Li (IEEE Fellow)

Advisor: Prof. Changbin Yu (Fellow of the Australian Academy of Technology and Engineering)

B.Sc. in Computer Science and English **Hebei University of Technology (211)** **Tianjin** *09/2016 - 06/2020*
Ranking: 1/70, GPA: 3.94/4.00

Outstanding Student Award (Top 1.5%)

Research Experience

[Paper] Large Language Model Applications

1. **Chenrui Duan**, et al. FGBERT: Function-Driven Pre-trained Gene Language Model for Metagenomics. (**AAAI** 2025 Under review)
Developed a large pre-trained language model based on 100 million metagenomic sequences, incorporating gene masking and triplet contrastive learning strategies to improve understanding of unknown gene regions. Built the first benchmark tool for this field, addressing complex functional relationships among sequences.

2. **Chenrui Duan**, et al. OpenMeta: Function-Driven Pre-trained Gene Language Model for Metagenomics. (**ICLR** 2025 Under review)
Developed the first comprehensive benchmark for metagenomic functional prediction, integrating 23 models across three hierarchical levels. The project applied multimodal fusion and multitask learning frameworks to handle multi-species interactions, and designed standardized data processing and evaluation workflows to improve task automation.

Generative Models

3. **Chenrui Duan**, et al. PhyloGen: Language Model-Enhanced Phylogenetic Inference via Graph Structure Generation. Accepted by **NeurIPS** 2024.
Proposed a generative phylogenetic inference model, utilizing a pre-trained language model and graph neural network to generate tree structures with linear complexity in branch length optimization. The model uses a scoring function to guide gradient optimization, accelerating convergence and improving computational efficiency.

4. **Chenrui Duan**, et al. MDTree: A Masked Dynamic Autoregressive Model for Phylogenetic Inference. (**ICLR** 2025 Under review)
Proposed an autoregressive generative model based on a diffusion network, leveraging dynamic masking mechanisms to overcome autoregressive model performance bottlenecks. The model applies multi-head attention and recursive node embedding modules to improve computational efficiency, while optimizing training stability to enhance generation speed and inference accuracy.

Multimodal Models

5. Zelin Zang*, Yongjie Xu*, **Chenrui Duan***, et al. A Review of Artificial Intelligence based Biological-Tree Construction: Priorities, Methods, Applications and Trends. Accepted by **Advanced Science** 2025.
Reviewed the application of generative models and large language models in phylogenetic inference, explored multimodal data fusion strategies for biological tree construction, and proposed directions for optimizing multimodal feature representation and generation capabilities.

6. Zelin Zang, Liangyu Li, Yongjie Xu, **Chenrui Duan**, et al. Must: Maximizing Latent Capacity of Spatial Transcriptomics Data. Accepted by **BIBM (CCF-B)**, 2024.
Developed a multimodal fusion model based on GNN and manifold learning, integrating gene expression and spatial data to construct a unified latent representation, improving analysis performance by 10%.

Medical Image Segmentation

As the second author (advisor as the first author), published two papers on medical image segmentation. Proposed a

gradient vector flow model based on manifold learning and an active contour model based on Hessian matrix, effectively improving boundary detection in complex scenes.

7. Ziyang Zhang, **Chenrui Duan**, et al. GVFOM: a novel external force for active contour based image segmentation[J]. **Information Sciences**, 2020, 506: 1-18. (SCI Q1)
8. Shoujun Zhou, **Chenrui Duan**, et al. Image Segmentation Using Active Contours with Hessian Based Gradient Vector Flow External Force[J]. **Pattern Analysis and Applications**, 2020, 506: 1-18. (SCI Q3)

[Invention patent]

Duan Chenrui, Zang Zelin, Xu Yongjie, Li Ziqing. A function-driven metagenomic pre-training gene language model system. 202410678198.2.
Duan Chenrui, Zang Zelin, Li Siyuan, Xu Yongjie, Li Ziqing. A developmental tree inference method based on a biological large language model. 202411528299.8.
Yu Changbin, Zhu Mingjian, **Duan Chenrui**, Xiong Haoliang, Jin Wei. A video stream description generation method using an intelligent terminal and a server. 202010810278.0.
Yu Changbin, Zhu Mingjian, **Duan Chenrui**, Mo Yuanqiu, Yu Changjun. A video description generation method for compressed videos. 202010810293.5.

Research Projects

Applications of Large Language Models

1. Antibiotic Resistance Gene Prediction Using Genome-Wide Pre-trained Model *Project Lead 10/2023 - present*

Collaborated with Prof. Zheng Jusheng's lab at Westlake University, leveraging a pre-trained model based on millions of genome sequences to capture resistance features. Utilized multi-head self-attention mechanisms to identify complex dependencies between gene fragments, improving the accuracy of antibiotic resistance gene identification. The model also successfully detected horizontal gene transfer events for the first time. Produced 2 AI top conference submissions and 1 joint submission to Nature Biotechnology.

Video Generation

2. Zhijiang Cup Global AI Algorithm Competition (Video Generation and Description Challenge) *Project Lead 06/2019 - 10/2020*

Led video generation and description tasks, proposing a multi-module fused network architecture. Used spatiotemporal attention mechanisms to optimize temporal consistency and applied generative adversarial networks to improve video resolution and diversity. The model successfully identified objects and relationships in videos, generating coherent natural language descriptions. Achieved 2nd place out of 1400 teams in 2020 and 2nd out of 1700 teams in 2019. Related research Video Captioning in Compressed Video was accepted at ICPR 2021.

Professional Internships

Research Assistant **Zhongzhi Future AI Research Institute** **Nanjing** *06/2020 - 09/2020*
Developed video understanding algorithms, optimizing spatiotemporal feature extraction models for video analysis.

Visiting Student **Technical University of Munich** **Munich, Germany** *02/2020 - 06/2020*
Collaborated with Prof. Sandra Hirche's team on research in machine learning and multi-agent systems.

Visiting Student **SUPINFO** **Paris, France** *06/2019 - 06/2020*
Conducted research projects related to image processing and computer vision as part of a CSC exchange program.

Awards & Honors

Zhejiang University Outstanding Graduate Student *09/2021 - 09/2023*

Westlake University Freshman Scholarship *(2/104)* *09/2020*

National Scholarship *06/2018*

Hebei University Top 10 Students *10/2019*

First Class Scholarship *09/2016 - 09/2020*

Skills

Programming Languages: Python, Pytorch, LaTex, C/C++, R, MATLAB;
English: CET-6: 539; CET-4: 588; National English Contest: First Prize