Guantian Zheng

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EDUCATION

Huazhong University of Science and Technology (HUST) 09/2022-06/2026

- Bachelor of Engineering in Integrated Circuit Design and Integrated System
- GPA: 4.25/5.0; Average Score: 87.7/100

RESEARCH INTERESTS

Computer Vision, Autonomous Driving, Trajectory Prediction, Brain-Computer Interface

PUBLICATIONS

1.Zhang, Z., Qiu, X., **Zheng, G.**, Gu, X., Chi, G., Gao, H.A., Wang, L., Liu, Z., Li, X., Gilitschenski, I., Li, H., Zhao, H., and Zhao, H., 2025.
Delving into Mapping Uncertainty for Mapless Trajectory Prediction. *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2025)*. *arXiv preprint arXiv:2507.18498*.

2.Zhang, Z., Li, X., Zou, S., Chi, G., Si, Q., **Zheng, G.**, Wang, L., Zhao, H., and Zhao, H., 2025.
Chameleon: Fast-slow Neuro-symbolic Lane Topology Extraction. *IEEE International Conference on Robotics and Automation (ICRA 2025, Oral Presentation)*. *arXiv preprint arXiv:2503.07485*.

3.Zhang, Z., **Zheng, G.**, Zou, S., Wang, L., Zhao, H., and Zhao, H., 2025
Unified Map Prior Encoder for Mapping and Planning *(ICRA 2026 submission)*

RESEARCH EXPERIENCES

***Research Assistant*, Autonomous Intelligence Lab (AutoLab), Westlake University** 06/2025-Present

Advisor: Assistant Professor Kaicheng Yu

Team Leader, **TrafficGenBench: Generative Benchmark for AI Reasoning in Traffic Scenarios**

- Identified limitations of static autonomous driving benchmarks in evaluating AI reasoning for complex traffic rule scenarios, especially rule conflicts (like traffic officer gestures vs. traffic lights)
- Designed a **programmable, controllable traffic scene generator** using real-world editing, creating highly realistic scenarios with **L1-L5 complexity** for systematic edge-case evaluation beyond existing datasets
- Developed a novel "**question-answer-reasoning chain**" evaluation framework to assess VLM/VLA models' scene understanding, rule compliance, and logical reasoning beyond traditional perception metrics
- Established a paradigm shift from passive "describing the world" evaluation to active "**generating the world**" adversarial capability assessment, providing targeted training data to improve model robustness

***Research Assistant*, Institute for AI Industry Research (AIR), Tsinghua University** 06/2024-Present

Advisor: Assistant Professor Hao Zhao

Team Leader, **Unified Map Prior Encoder for Mapping and Planning (Code)**

- Investigated the underutilization of heterogeneous map priors in autonomous driving, identifying pose drift, inconsistent availability, and representation gaps as key barriers to effective multi-modal map fusion
- Developed a **unified dual-branch encoder**: vector priors (**HD/SD maps**) via confidence-biased cross-attention, raster priors (**satellite, rasterized SD**) via FiLM-conditioned ResNet-18, enabling seamless fusion of arbitrary prior subsets
- Designed frame-wise SE(2) pre-alignment and multi-frequency sinusoidal point encoding for vector maps, combined with SE(2) micro-alignment for raster inputs, effectively handling pose drift and scale mismatches
- Achieved consistent **mAP improvements of +5.9 on MapTRv2** (61.5→67.4) and **+5.3 on MapQR** (66.4→71.7) across nuScenes and Argoverse2, demonstrating **powerset robustness** where all-prior-trained models outperform single-prior baselines even when only one prior is available at test time
- Extended to end-to-end planning on nuScenes, reducing **trajectory L2 error by 42%** (0.72→0.42m) and **collision rate by 45%** (0.22%→0.12%), surpassing recent prior-injection methods

Team Leader, **Delving into Mapping Uncertainty for Mapless Trajectory Prediction (Code)**

- Investigated the effect of online-generated High-Definition (HD) map uncertainty on mapless trajectory prediction in autonomous driving, identifying the vehicle's kinematic state as a key overlooked factor
- Proposed a lightweight, self-supervised **Proprioceptive Scenario Gating** module that adaptively integrated map uncertainty into trajectory prediction based on the ego vehicle's future motion dynamics
- Designed a novel **Covariance-Based Map Uncertainty** model using 2D Gaussian distributions to better capture road geometry and improve robustness over prior Laplace-based approaches
- Reproduced and benchmarked four state-of-the-art online map construction models (**MapTR**, **MapTRv2**, **MapTRv2-Centerline**, **StreamMapNet**) and integrated them with two representative trajectory predictors (**Transformer-based HiVT**, **GNN-based DenseTNT**) for full-stack evaluation
- Conducted extensive experiments on the **nuScenes** dataset, achieving up to **23.6% performance gain** over prior SOTA methods in trajectory prediction metrics, including minADE, minFDE, and Miss Rate
- Performed ablation studies comparing proprioceptive gating with exteroceptive CLIP/ResNet-based

alternatives, demonstrating superior accuracy and **10-30x inference speed**, contributing significantly to the real-time deployment of mapless trajectory prediction systems

Team Member, **Chameleon: Fast-slow Neuro-symbolic Lane Topology Extraction (Code)**

- Developed a neuro-symbolic algorithm combining symbolic reasoning over detected instances with **Chain-of-Thought-based VLMs** to handle corner cases in lane topology extraction
- Proposed a **program synthesis framework** that generated executable Python codes based on few-shot visual/text prompts, expert rules, and API descriptions to reason over spatial relationships
- Designed a benchmark of **dense visual prompting Visual Question Answering (VQA) tasks** (e.g., lane adjacency, direction matching, intersection inclusion) and tested with GPT-4o, GPT-4-vision, LLaVA, and ResNet18-based MLP, to evaluate VLMs' capabilities in understanding complex 3D driving scenes
- Achieved **consistent improvements** on the **OpenLane-V2** dataset in 3-shot settings, **matching or outperforming** fully supervised baselines in lane-traffic topology inference without additional fine-tuning
- Reduced inference time from **>200s to 0.1-8s per frame**, with ablation studies showing that incorporating expert rules and few-shot examples improves symbolic reasoning accuracy by nearly **5%**
- Delivered a cost-efficient and scalable solution for real-time deployment in mapless autonomous driving, significantly lowering computational cost and carbon footprint

Team Member, **Enhanced Point Cloud Reconstruction with PTv3 and Dual Hyper in SVDFormer**

- Designed a cohesive **dual-hypernetwork** architecture by introducing **hyperembedding** in the SDG module's embedding layer, combined with HyperCD loss replacement, ensuring architectural elegance and compatibility while significantly improving reconstruction quality
- Integrated **PTv3** as the 3D backbone with z-order and Hilbert curve-based spatial ordering, expanding receptive field, and accelerating processing speed to offset dual hypernetwork computational overhead
- Achieved **17% performance gain** on ShapeNet-55 (CD-avg 0.83→0.69) while maintaining efficient inference and training speed

HUST, National College Student Innovation Program 02/2024-05/2024

Advisor: Dr. Dawei Ye

Team Leader, **Brain-Controlled Robotic Arm**

- Developed an innovative brain-computer interface system for real-time EEG-based control of a robotic arm, assisting paralyzed individuals with daily tasks such as eating, gripping, and writing
- Implemented signal preprocessing (noise filtering, artifact removal) to extract clean neural signals from motor cortex activity using commercial EEG devices
- Applied machine learning algorithms, including Common Spatial Pattern (CSP) and Support Vector Machine (SVM) for feature extraction and classification, achieving **82.4% accuracy** in real-time recognition of **five degrees of freedom right-hand motor intentions** with **sub-second latency for practical BCI applications**
- Engineered robust backend system architecture for seamless integration of EEG acquisition, real-time processing, and robotic arm control, with fail-safe mechanisms and calibration for reliable execution

HONORS & AWARDS

- ***Academic Excellence Scholarship,*** HUST 04/2025
- ***Second Prize,*** **12th Hubei Provincial Undergraduate Mathematics Competition**, Hubei Province Mathematical Society 12/2023
- ***Self-Motivation and Diligence Scholarship,*** HUST 10/2023
- ***Academic Excellence Scholarship,*** HUST 04/2023
- ***Third Prize,*** Undergraduate Group, **2022 Asia and Pacific Mathematical Contest in Modeling,** Beijing Society of Image and Graphics 02/2023

COURSERA CERTIFICATES

Advanced Learning Algorithms (04/2024) and *Supervised Machine Learning: Regression and Classification* (03/2024), offered by DeepLearning.Al and Stanford University

COMPUTER SKILLS

C, Python, MATLAB, SPSS, Verilog, Keil, TensorFlow, PyTorch