

# Zhaoheng Wang

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Research interests: **Electric Vehicles, Coordination Control, Multi-agent System and Euler-Lagrange Model**

## EDUCATION

Jiangsu University, Zhenjiang, China

- M.Eng., Control Engineering (Electronic and Information Engineering)

Sep.2022 – Jun.2025

Southeast University, Nanjing, China

- B.Eng., Electrical Engineering and Automation

Sep.2018 – Jun.2022

## RESEARCH EXPERIENCE

Laboratory of Electric Vehicle Drive and Intelligent Control, Jiangsu University

- **Topic: Euler-Lagrange-Model-Based Torque Assignment Control for Multiple In-Wheel Motors with Voltage Vectors Integrated Modulation**

Independent Researcher, Supervisors: Prof. Xiaoyong Zhu, Prof. Lei Xu and Prof. Li Quan

Sep.2023 – Jul.2024

### Background

- Current coordination strategies often overlook the nonlinear factors inherent in distributed multi-wheel motor drive systems, especially the flexible coupling caused by the rigid components of the vehicle chassis. This oversight can lead to speed instability and torque imbalances, which may ultimately result in complications such as vehicle slippage and dragging.

### Contributions

- Constructed a joint model for multiple in-wheel motors, using the Euler-Lagrange framework to incorporate electromagnetic and mechanical coupling within a distributed drive system.
- Proposed a real-time torque distribution control law that derived from the joint model, integrates the interconnection and friction damping matrices, with voltage stability tracking included as a constraint.
- Dynamic decoupling of state variables is achieved by proposing a dynamic tuning strategy for the interconnection and friction damping coefficients.

### Achievements

- Manuscript submitted to *IEEE Transactions on Industrial Electronics*, and is under review.

- **Topic: Participation in National Natural Science Foundation of China (Grant No. 5193000544, Principal Investigator: Xiaoyong Zhu)**

Research Assistant, Supervisors: Prof. Xiaoyong Zhu, Prof. Lei Xu and Prof. Wen-Hua Chen

Sep.2022 – Sep.2023

### Background

- The coordination strategy of existing distributed drive systems primarily emphasizes torque allocation by upper-level controllers, often neglecting the performance indicators of each in-wheel motor and the coordination among motor controllers. Furthermore, the redundancy of multi-motor controllers and multi-actuators in distributed drive systems results in low fault tolerance for signal transmission.

### Contributions

- Proposed the integrated modulation control concept, which reduces the complexity of the underlying controller architecture and serves as a framework for further algorithms to achieve high dynamic performance for individual motor drives while facilitating rapid coordination among multiple motors.
- Proposed an integrated direct torque control strategy that utilizes multiple voltage vector modulation for a distributed multiple in-wheel motor drive system, grounded in integrated modulation control concept.
- Developed and analyzed frequency ratio integrated modulation and virtual vector integrated modulation methodologies based on multiple voltage vector modulation principle.
- Invented a multiple in-wheel motor integrated modulation drive system, incorporating a vehicle controller, multi-mode secondary devices, and integrated drivers.

### Achievements

- Paper has been published in *IEEE Transactions on Industrial Electronics* (Early Access).
- Chinese Invention Patent Application accepted (Publication Date: 12-Nov-2024).

Centre for Professional and Continuing Education, Nanyang Technological University

- **Topic: Robotics, Automation and Internet of Things (IoT)**

Visiting Student, Supervisor: Prof. Xie Ming

Jan.2023 – Feb.2023

- Reviewed Research on Information Security in Smart Medical Systems.

- Research and studied robotics automation, which provides a foundation for my future research.
- Achievements**
- Received the Certification of Distinction. (Access to [certification](#))
  - Won the title of the Best Presenting Team. (Access to [certification](#))

School of Electrical Engineering, Southeast University

➤ **Topic: Active Control of Electromagnetic Suspension Force and Disturbance Rejection in Systems**

*Independent Researcher & principal investigator*, Supervisor: Prof. Xinghe Fu

Sep.2021 – Jun.2022

**Background**

- The purpose of the project is to make progress on achieving high-precision control for magnetic suspension platforms in order to address the challenges posed by traditional methods that are often less accurate and ineffective

**Contributions**

- Applied Taylor series expansion to linearize the nonlinear electromagnetic suspension system model and derived its transfer function.
- Conducted comprehensive electromagnetic analyses of the suspension platform using Ansys Maxwell.
- Developed an active disturbance rejection system capable of performing independent, decoupled analysis of both internal and external disturbances. Utilized an extended state observer for their identification and estimation, and implemented feedforward compensation based on the disturbance estimates to minimize the nonlinear system's reliance on precise models.
- Assisted in the construction of a four-point magnetic suspension platform.

**Achievements**

- Received an 'Excellent' (A) grade for my Bachelor's Graduation Project in 2022.
- Served as principal investigator for a project under the National College Students' Innovation and Entrepreneurship Training Program (NCETP), successfully completing it with a passing evaluation. (Access to [poster](#))
- Successfully presented the outcomes of the NCETP project at the 15th Innovation and Entrepreneurship Achievement Exhibition, Southeast University, 2020.

## PUBLICATIONS

<b>Journals</b>	➤ <b>Zhaoheng Wang</b> , Xiaoyong Zhu, Lei Xu, et al., (In Press), “Multi-Voltage-Vector-Modulation-Based Integrated Direct Torque Control of Dual In-Wheel PM Motors for Distributed Drive Electric Vehicles,” <i>IEEE Transactions on Industrial Electronics</i> , 2024. <b>Early Access</b> , doi: 10.1109/TIE.2024.3482000. (SCI Q1, JCR Q1) (Access to <a href="#">IEEE Xplore</a> )
<b>Under Review</b>	➤ <b>Zhaoheng Wang</b> , Lei Xu, Xiaoyong Zhu et al., “Euler-Lagrange-Model-Based Torque Assignment Control for Dual In-Wheel PM Motors with Voltage Vectors Integrated Modulation,” <i>IEEE Transactions on Industrial Electronics</i> . (SCI Q1, JCR Q1)
<b>Patent</b>	➤ Xiaoyong Zhu, <b>Zhaoheng Wang</b> , Lei xu, Li Quan., “An Integrated Modulation Drive System for Multiple In-Wheel Motors and Its Control Method” Chinese Invention Patent [P]: CN202411247307.1, 2024-11-12. (Co-author)

## PROFESSIONAL SKILLS AND AWARDS

- **Computer Competencies:** MATLAB/Simulink, Keil, C++, Origin, Ansys Maxwell, Network Technology.
- **Technical Instruments:** Adept in utilizing advanced technical instruments, including the dSPACE DS1007 controller, RTUnit RTU-BOX204 controller, ACS580-C26-17A0-3B universal servo driver, and STM32F103ZET6 ARM Cortex-M3 microcontroller.
- **Awards:** First-Class Graduate Academic Scholarship for the Academic Year 2022-2023, Jiangsu University; Second-Class Graduate Academic Scholarship for the Academic Year 2023-2024, Jiangsu University; National Computer Rank Examination (NCRE) level 3 Certificate in Network Technology. (Access to [Certification](#))
- **IELTS:** Band 6.5 (Listening 7.5, Reading 6.0, Writing 6.0, Speaking 6.0)