北京理工大學
BEIJING INSTITUTE OF TECHNOLOGY

27 Fall PhD Application Research Portfolio

Chengye Wang

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Homepage: https://leowang1820.github.io/

Beijing, China

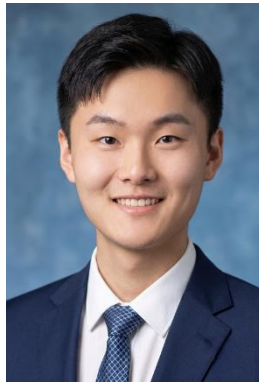
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2 Research Experience

3 Future Research Interest

Self Introduction



- Name: Chengye Wang
- Nationality: Chinese
- Education Background:

Bachelor Degree (2020.9-2024.06)
Jilin University (Project 985), Changchun, China
Major: Vehicle Engineering **Supervisor:** Prof. Nan Xu
GPA: 3.73/4.0, Top 5% **Awards**: Outstanding Graduate
Thesis: "Vehicle trajectory planning method based on polynomial curve optimization."

Postgraduate Student (2024.9-2027.06)
Beijing Institute of Technology (Project 985), Beijing, China
Major: Mechanical Engineering **Supervisor:** Prof. Yechen Qin
GPA: 86/100 **Awards**: Outstanding Freshman Scholarship
Research Interests: Vehicle driving stability analysis, Chassis control of Distributed Drive Electric Vehicle (DDEV), Trajectory planning.

- Research Skills:

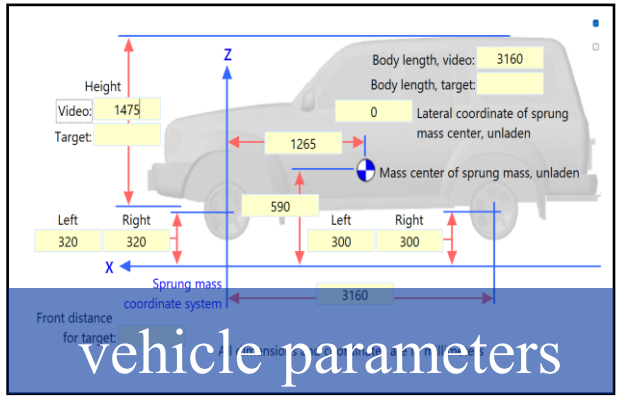
Matlab/Simulink, CarSim, Python, Ubuntu/ROS, C++, Latex, Automotive hardware and software debug, and Microsoft Office.

Research Background 1: Vehicle Driving Stability Analysis

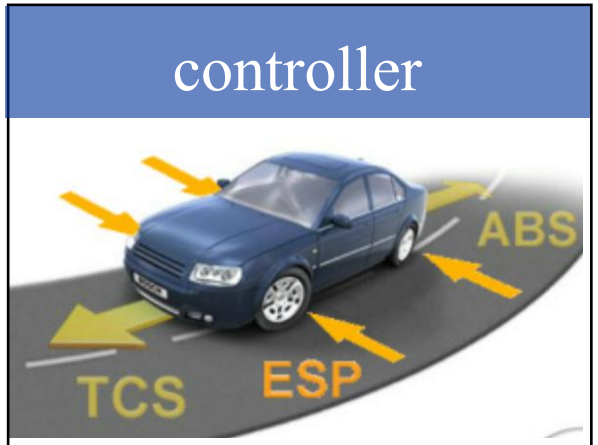
■ Unclear stability analysis under multidimensional factors

Driving Factors





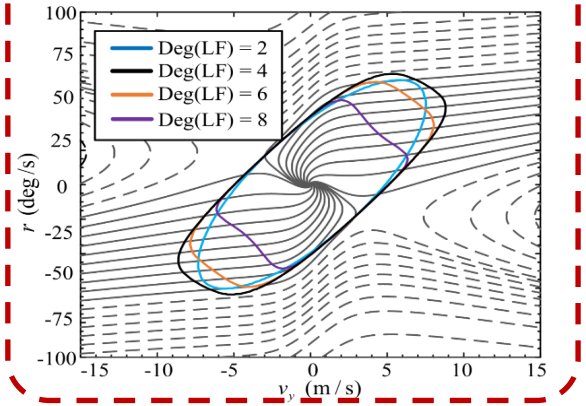
Control Ability





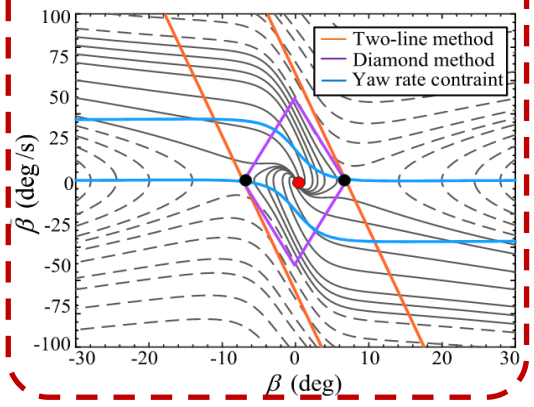
Stability Analysis Method

➢ Lyapunov Function Method



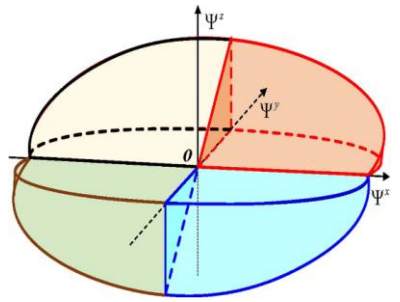
Inability to Model Complex Nonlinearities

➢ Phase Plane Method



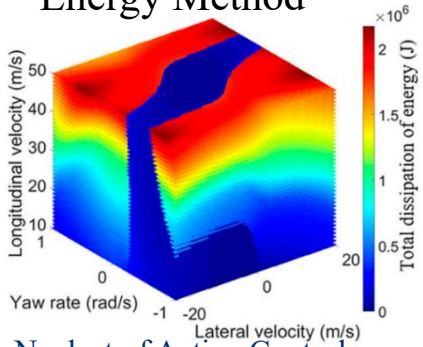
Based on open-loop assumptions

➢ Tire Force Analysis Method



Tire saturation doesn't equal vehicle instability

➢ Energy Method

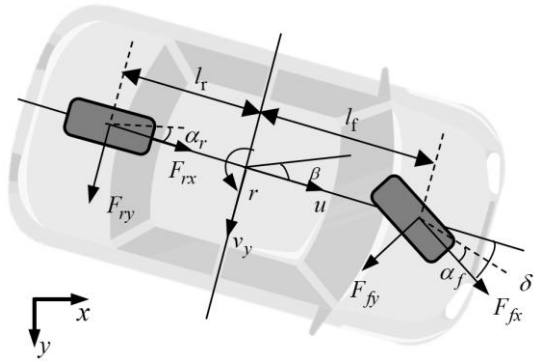


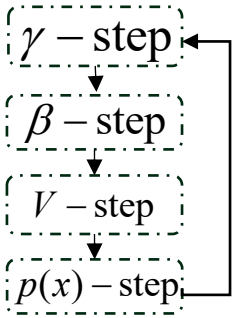
Neglect of Active Control

Physical Parameters, Environment, and Control Ability Jointly Determine the Stability Limit

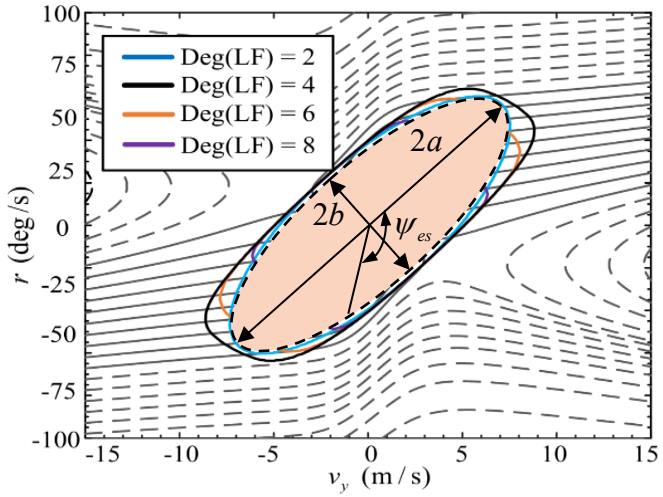
Research Experience 1: Vehicle Driving Stability Analysis

Lyapunov Function Method-Sum of Squares Programming (SOSP)

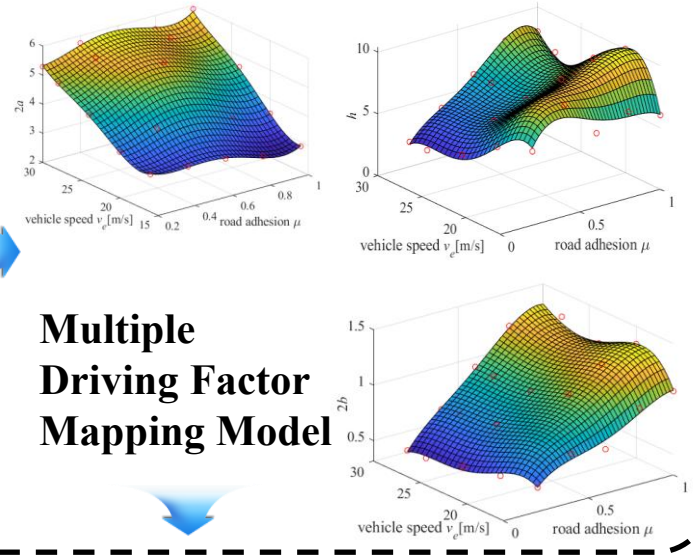




SOSP Method



Offline Stability Domain Calculation



Multiple Driving Factor Mapping Model

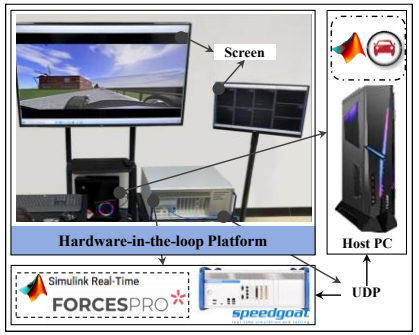
Elliptical constraints: $g(v_y,r)=\left(\frac{\cos^2 f_{\psi_{es}}}{f_a^2}+\frac{\sin^2 f_{\psi_{es}}}{f_b^2}\right)r+2\cos f_{\psi_{es}}\sin f_{\psi_{es}}\times\left(\frac{1}{f_a^2}-\frac{1}{f_b^2}\right)v_y r+\left(\frac{\cos^2 f_{\psi_{es}}}{f_a^2}+\frac{\sin^2 f_{\psi_{es}}}{f_b^2}\right)r-1$

MPC tracking controller

$$u^* = \arg\min J$$

$$\text{s.t.}\dot{x}^{\text{trk}} = f(x,u), g(v_y,r)\big|_{f_a,f_b,f_{\psi_{es}}} \le 0$$

$$u_{\min} \le u \le u_{\max}, x_{\min} \le x \le x_{\max}$$



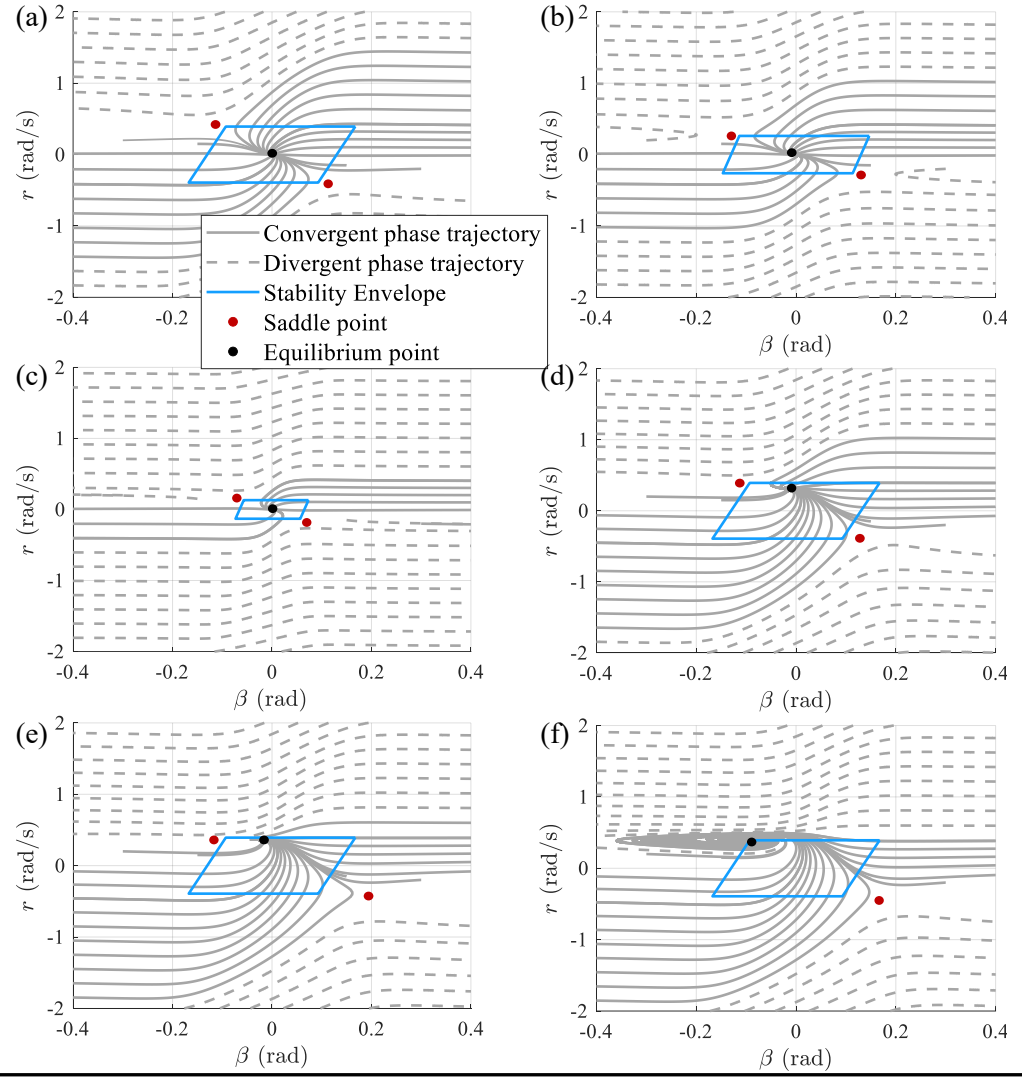
Related publications:

1. Yu Zhang, **Chengye Wang**, Fu Du, Mingming Dong, Yechen Qin, Ming Mao. "Dynamic Region of Stability Integrated Path-tracking Control for Intelligent Vehicles". **Chinese Journal of Mechanical Engineering**. **(accepted)**
2. **Chengye Wang**, Yu Zhang, Xuepeng Hu, Haipeng Qin, Guoli Wang, Yechen Qin. "Real-time multidimensional vehicle dynamic stability domain calculation and its application in intelligent vehicles", **SAE 2025 Intelligent and Connected Vehicles Symposium**, Chongqing, China. **(accepted)**

Research Experience 1: Vehicle Driving Stability Analysis

■ Analysis of Active Control in the Recovery of the Phase Plane Trajectory

Open-loop Phase Plane

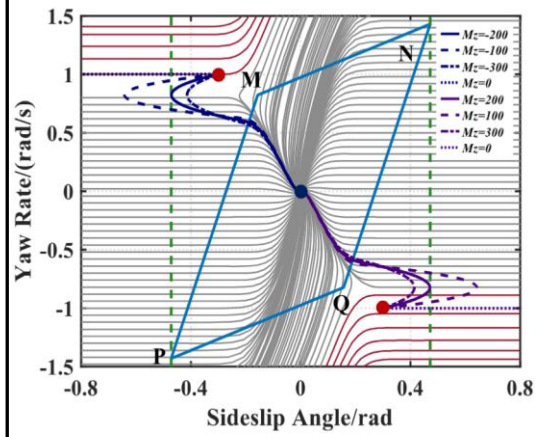


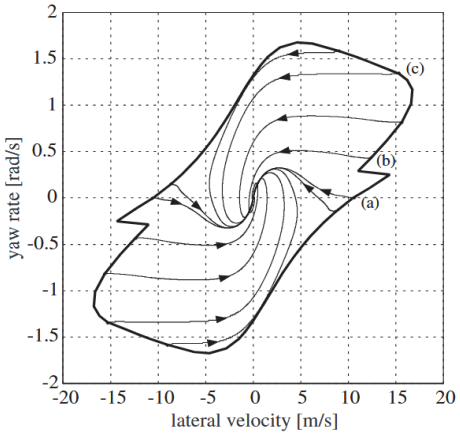
no control input

active control input

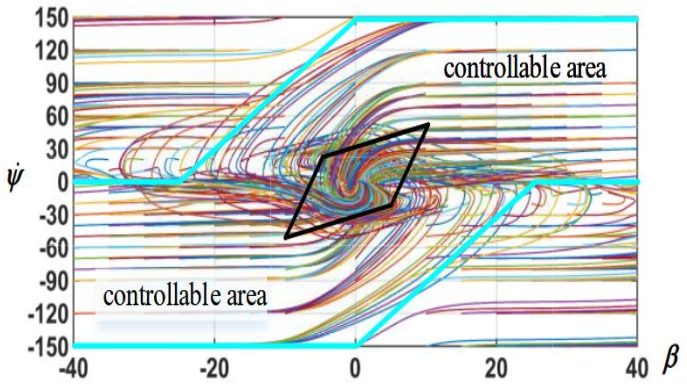
Phase Plane Considering Active Control Inputs

- Phase Trajectory Convergence via Direct Yaw Control (DYC):





- Phase Trajectory Convergence via Active Front Steering (AFS):



Research Experience 1: Vehicle Driving Stability Analysis

■ Specific Control Law – guided Controlled Stability Region (CSR)

Stability Control Law Design

Predictive Model:

$$\begin{cases}\dot{\beta}=\dfrac{1}{mv_x}\left[(F_{y,\mathrm{fl}}+F_{y,\mathrm{fr}})\cos\delta_f+(F_{y,\mathrm{rl}}+F_{y,\mathrm{rr}})\right]-r\\ \dot{r}=\dfrac{1}{I_z}\left[l_f(F_{y,\mathrm{fl}}+F_{y,\mathrm{fr}})\cos\delta_f-l_r(F_{y,\mathrm{rl}}+F_{y,\mathrm{rr}})+\dfrac{B_f}{2}(F_{y,\mathrm{fl}}-F_{y,\mathrm{fr}})\sin\delta_f+M_z^{\mathrm{stab}}\right]\\ \dot{v}_x=\dfrac{F_{x,\mathrm{all}}^{\mathrm{stab}}}{m}+v_x\tan\beta\cdot r\end{cases}$$

State/Control/Reference Definition:

$$x^{\mathrm{stab}}=[\beta,r,v_x]^\top\quad u^{\mathrm{stab}}=[M_z^{\mathrm{stab}},F_{x,\mathrm{all}}^{\mathrm{stab}}]^\top$$

$$x_{\mathrm{ref}}^{\mathrm{stab}}=[\beta_{\mathrm{ref}}=0,r_{\mathrm{ref}}=\mathrm{sgn}(\delta_f)\min\{v_x\delta_f/(L(1+Kv_x^2)),\mu g/v_x\},v_{x,\mathrm{ref}}=v_{x0}]^\top$$

Objective Function:

$$J^{\mathrm{stab}}=\int_t^{t+T_p}\left[w_{\mathrm{stab0ref}}(x^{\mathrm{stab}}-x_{\mathrm{ref}}^{\mathrm{stab}})^2+w_{\mathrm{stab0}u}(u^{\mathrm{stab}})^2+w_{\mathrm{stab0}\Delta u}(\Delta u^{\mathrm{stab}})^2\right]dt$$

MPC Control Law:

$$u^{\mathrm{stab}*}=\arg\min_{u^{\mathrm{stab}}}J^{\mathrm{stab}}$$

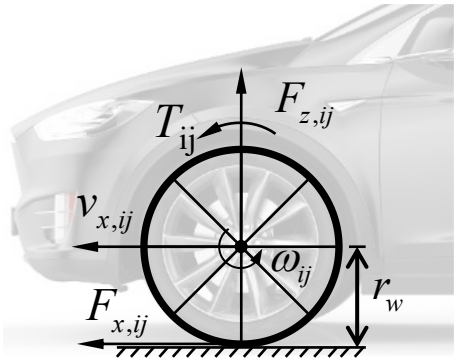
$$\text{s.t.}\dot{x}^{\mathrm{stab}}=f(x^{\mathrm{stab}},u^{\mathrm{stab}}),u_{\min}^{\mathrm{stab}}\le u^{\mathrm{stab}}\le u_{\max}^{\mathrm{stab}}$$

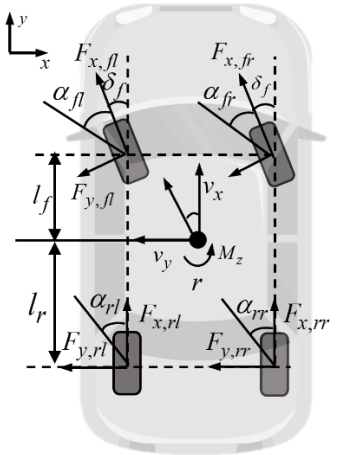
$u^{\mathrm{stab}*}=[T_{ij},\delta_f]^\top$

QP

Controlled Phase Trajectory Calculation

7 DOF Phase Plane Model: $\dot{x}=f(x,u)$





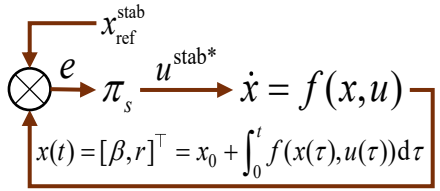
$$x=[\beta,r,v_x,\omega_{ij}]^\top\quad u=[T_{ij},\delta_f]^\top$$

$$x_0=[\beta_0,r_0,v_{x0},\omega_{ij0}]^\top$$

$$x(t)=x_0+\int_0^t f(x(\tau),u(\tau))\mathrm{d}\tau=\phi(t;x_0,u(\cdot))$$

$$\begin{cases}\dot{v}_y=\dfrac{1}{m}\left[F_{y,f}\cos\delta_f+F_{x,f}\sin\delta_f+F_{y,r}\right]-v_xr\\ \dot{v}_x=\dfrac{1}{m}\left[F_{x,f}\cos\delta_f-F_{y,f}\sin\delta_f+F_{x,r}\right]+v_yr\\ \dot{r}=\dfrac{1}{I_z}\left[l_fF_{y,f}\cos\delta_f-l_rF_{y,r}+M_z\right]\\ \dot{\omega}_{ij}=\dfrac{T_{ij}-F_{x,ij}r_w}{I_w},\beta=\arctan\left(\dfrac{v_y}{v_x}\right)\end{cases}$$

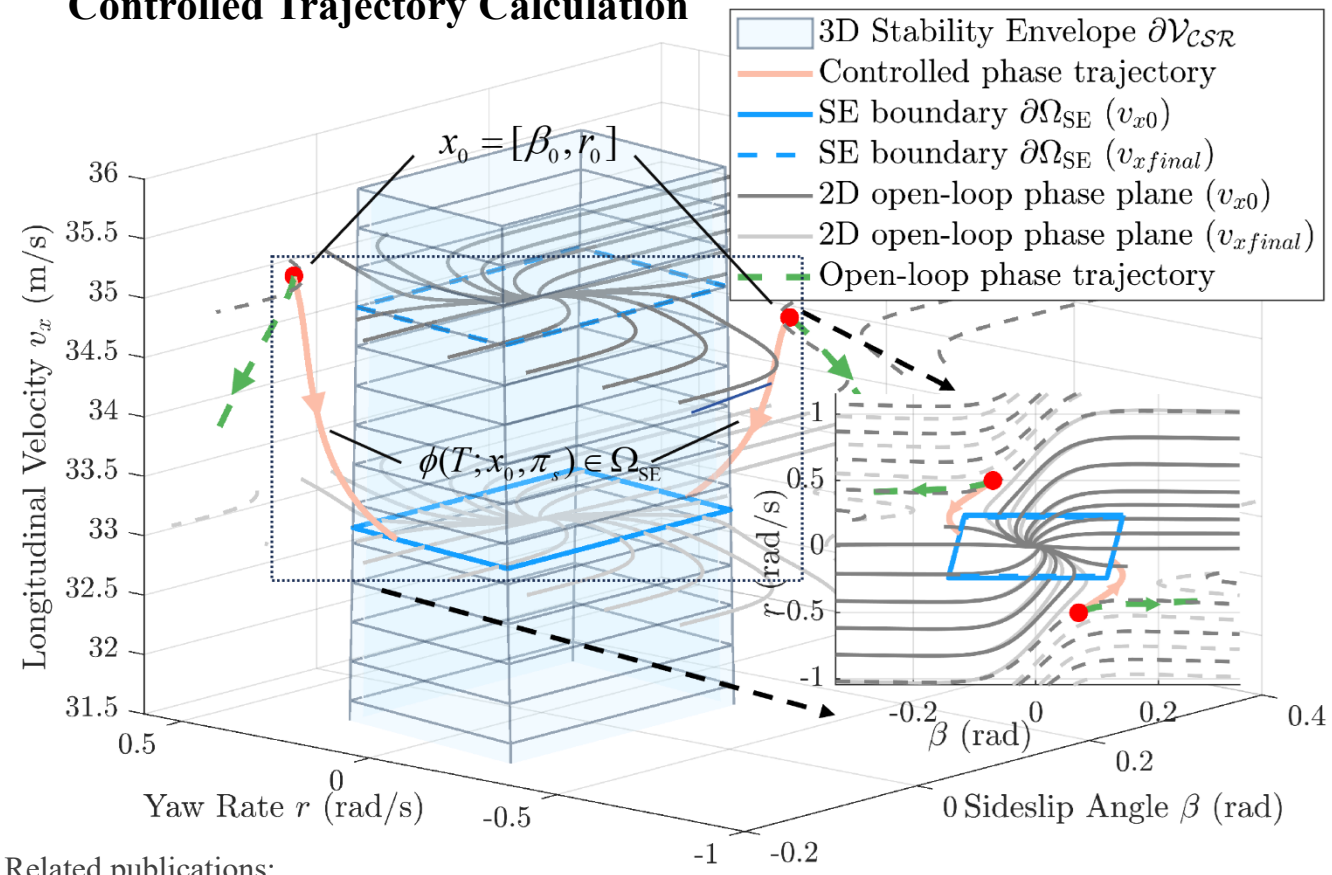
CSR Calculation:



Research Experience 1: Vehicle Driving Stability Analysis

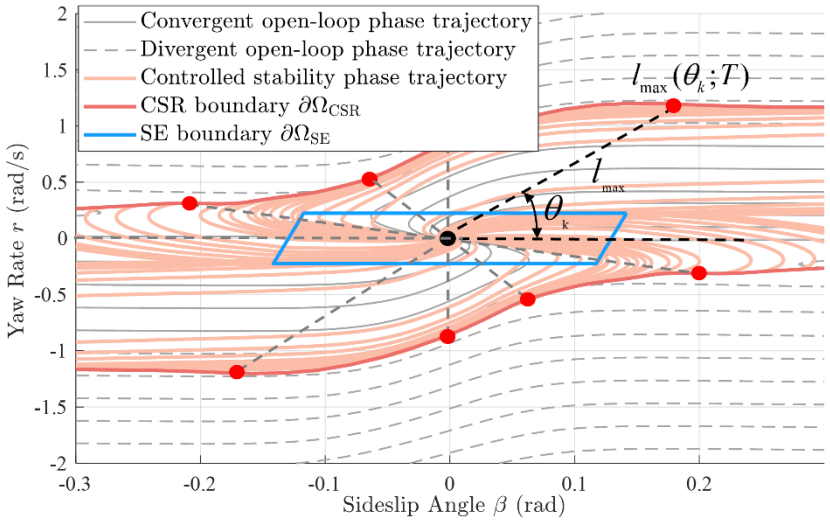
Quantification of Controlled Stability Region

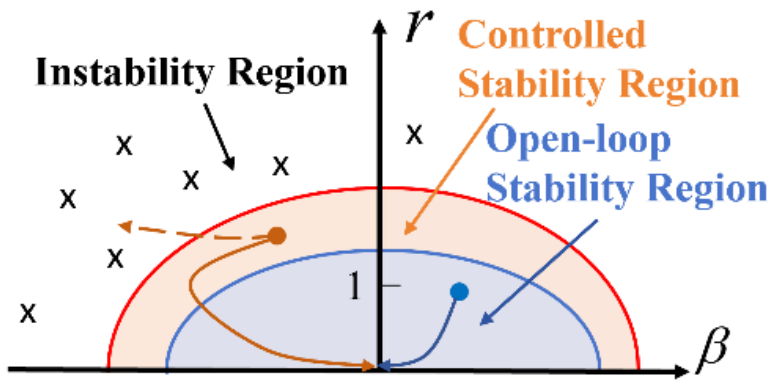
Controlled Trajectory Calculation



Offline Traversal

Forward-Simulated Radial Bisection





Related publications:

1. **Chengye Wang**, Yu Zhang, Xuepeng Hu, Shaoyang Shi, Jingqi He, Yechen Qin. "Coordinated Tracking and Stability Control of Automated Vehicles at the Limits: A Controlled Stability Region Approach**", 2026 IEEE 29th International Conference on Intelligent Transportation Systems (ITSC)**, Naples, Italy. **(accepted)**
2. **Chengye Wang**, Shaoyang Shi, Yu Zhang, and Yechen Qin. "Controlled Stability Region-Guided Lateral-Longitudinal TrajectoryTracking for Autonomous Vehicles. " **IEEE Transactions on Industrial Electronics.(Under review, IF=7.4, JCR Q1, Top)**

Research Background 2: Coordinated Tracking and Stability Control

Challenge of Motion Control



Hierarchical Architecture

Human Driver

Perception Layer
- localization
- perception

Planning Layer
- global-planning
- decision-making
- trajectory-planning

Control Layer
- tracking control
- stability control

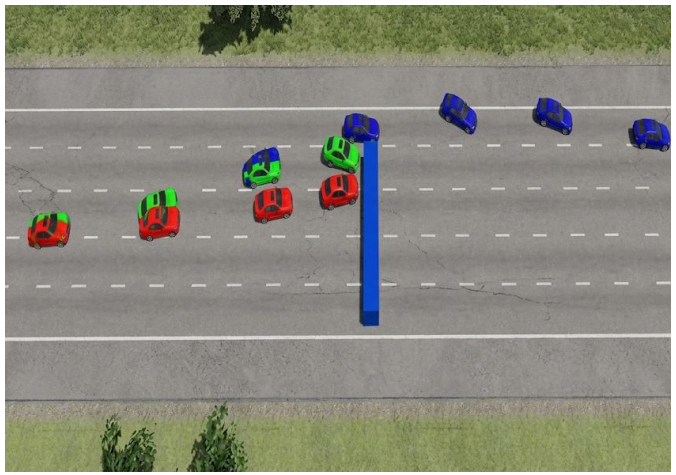
e2e



Stability Guarantee ⇄ **Tracking Accuracy Enhancement**



Safety Risk: Lack of strict stability bounds leads to loss of control.

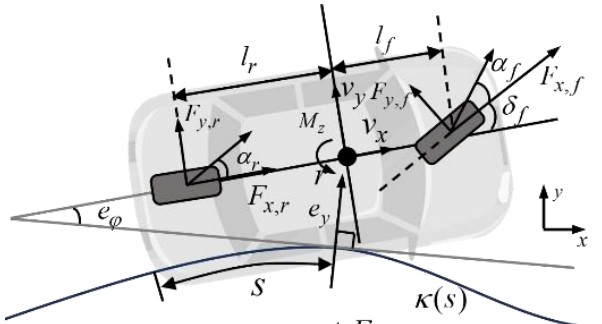


Maneuverability Loss: Over-conservative stability criteria limit maneuverability in extreme conditions.

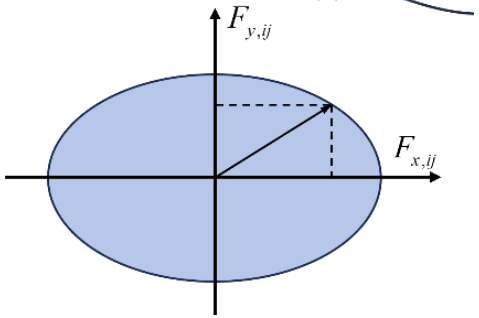
The Tracking-Stability Coordination is the Core Challenge in Motion Control

Research Experience 2: Coordinated Tracking and Stability Control

Longitudinal-Lateral Trajectory Tracking Controller

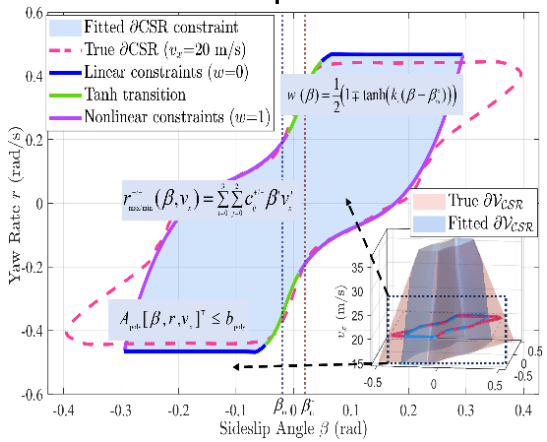


NMPC Predictive Model



Combined-slip Model

$$\left(\frac{F_{x,ij}}{\mu F_{z,ij}}\right)^2+\left(\frac{F_{y,ij}}{\mu F_{z,ij}}\right)^2\le 1$$



Stability Constraints

$$u^{\text{trk}*}=\arg\min J^{\text{trk}}$$

$$\text{s.t.}\dot{x}^{\text{trk}}=f(x^{\text{trk}},u^{\text{trk}}),h(x^{\text{trk}},u^{\text{trk}})\le 0$$

$$u_{\min}^{\text{trk}}\le u^{\text{trk}}\le u_{\max}^{\text{trk}},x_{\min}^{\text{trk}}\le x^{\text{trk}}\le x_{\max}^{\text{trk}}$$

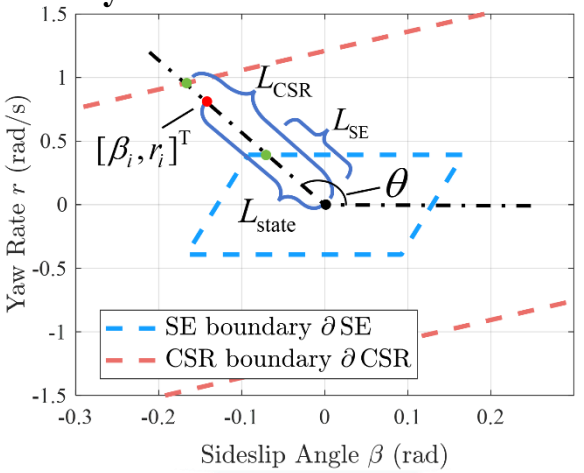
$$x_0^{\text{trk}}=\phi(t_c;x_{\text{meas}},u_{\text{prev}}^{\text{trk}*})$$

$u^{\text{trk}*}$

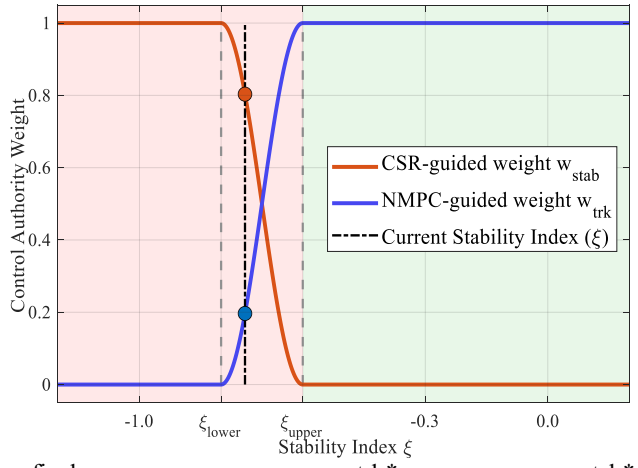
$u^{\text{stab}*}$

CSR-Guided Stability Fallback and Switching Strategy

Instability risk calculation:



Switching Strategy:



$$u^{\text{fianl}}(t)=(1-w_{\text{stab}})u^{\text{trk}*}(t)+w_{\text{stab}}u^{\text{stab}*}(t)$$

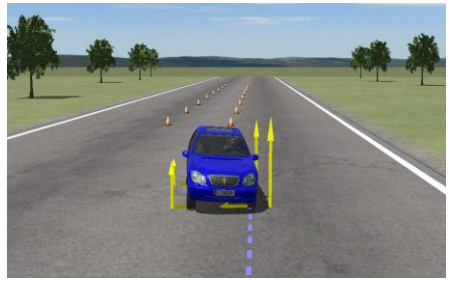
u^{fianl}

QP

Steer

Drive

Brake



Research Experience 2: Coordinated Tracking and Stability Control

■ Hardware-in-the-Loop (HiL) Platform



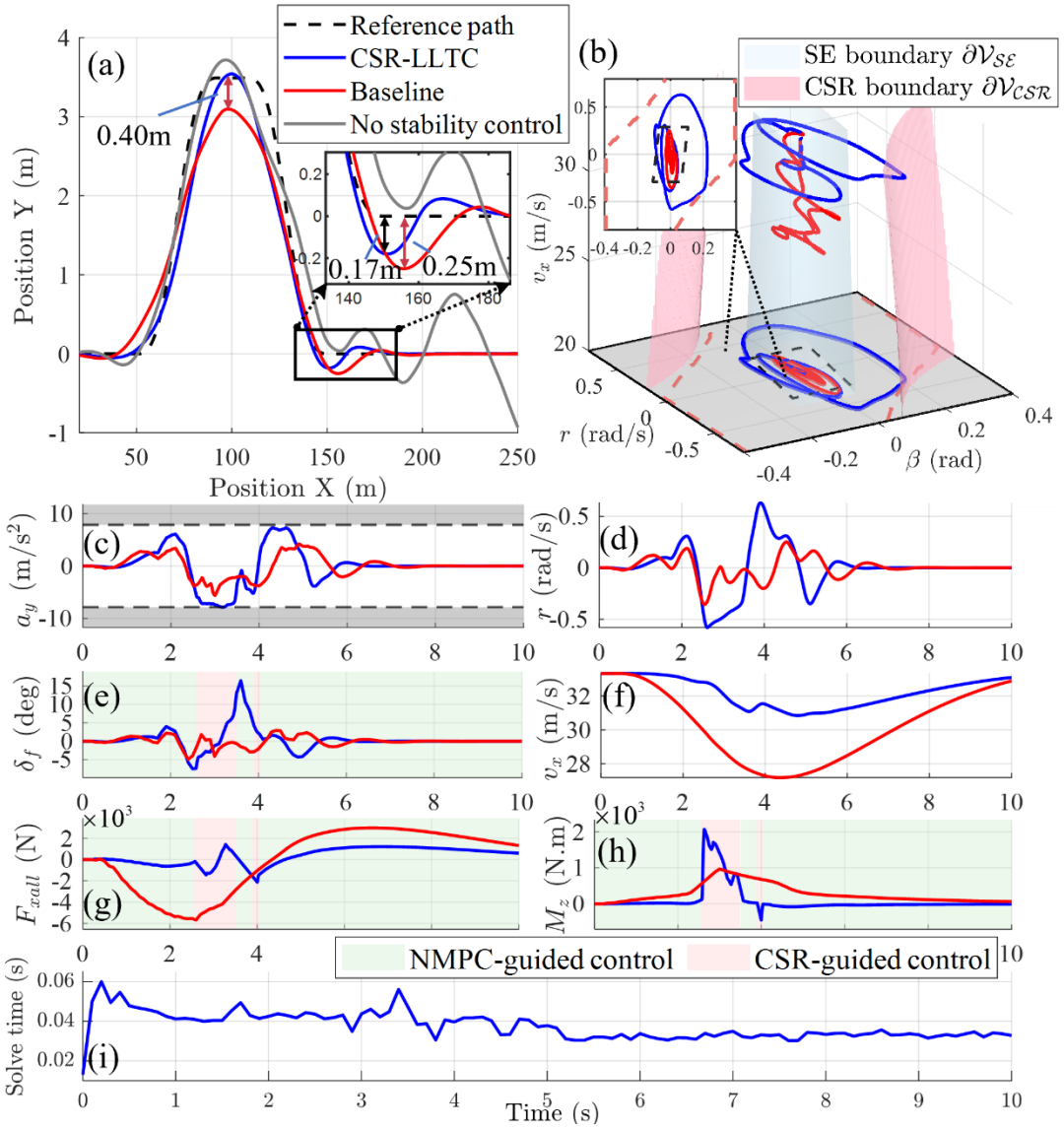


PARAMETERS OF THE TEST VEHICLE

Parameter	Value	Parameter	Value
m	2045 kg	r_w	0.345 m
I_z	4095 kg · m^2	l_f, l_r	1.265, 1.895 m
I_w	2 kg · m^2	B_f, B_r	1.605 m

Research Experience 2: Coordinated Tracking and Stability Control

Double Lane Change (DLC) under μ=0.8, $v_{x,ref}$=120km/h



Blue car: proposed
Red car: Baseline
Green car: no stability control

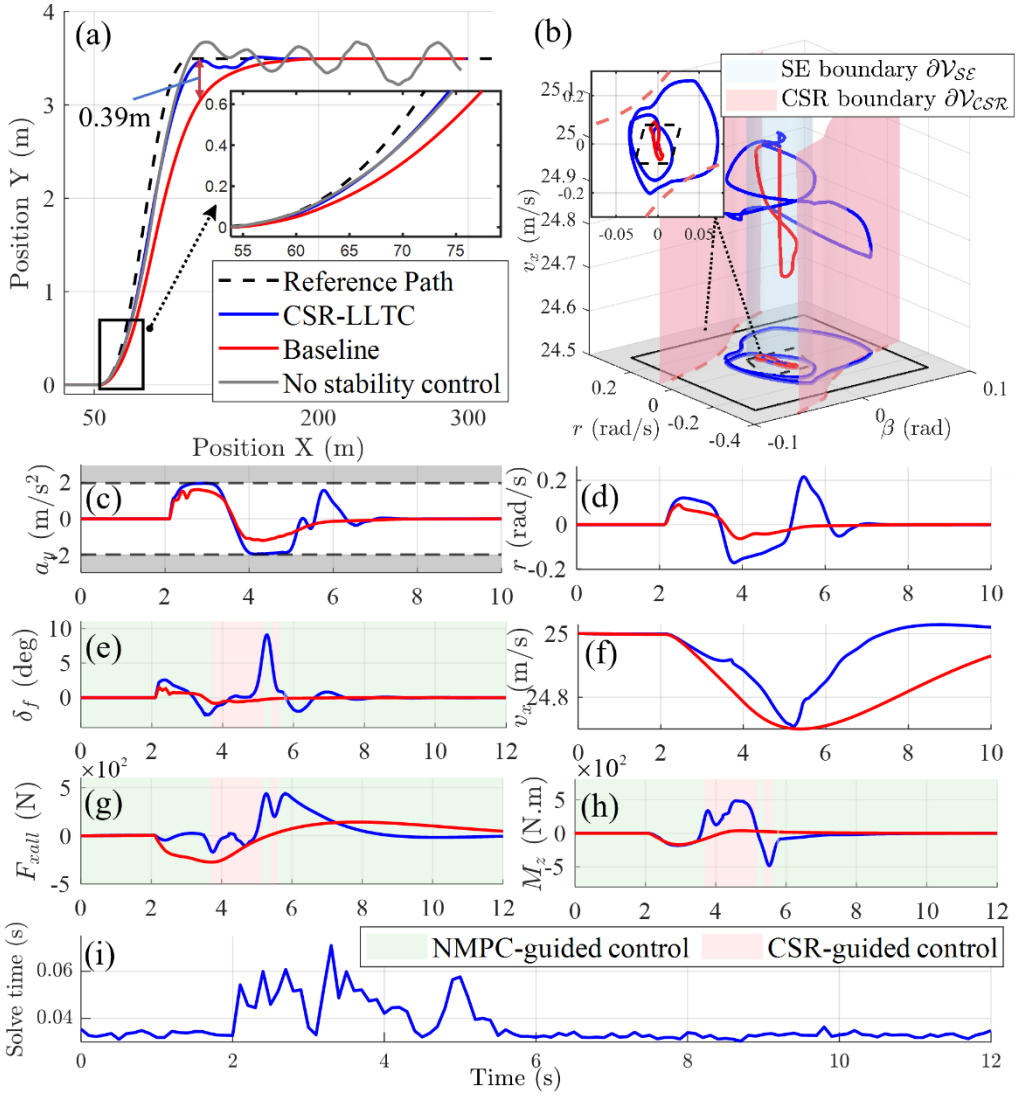


$e_{y,\mathrm{pk}} \downarrow 36.6\%$

$v_{x,\mathrm{avg}} \uparrow 7.5\%$

Research Experience 2: Coordinated Tracking and Stability Control

Lane Change (LC) under μ=0.2, $v_{x,ref}$=90km/h



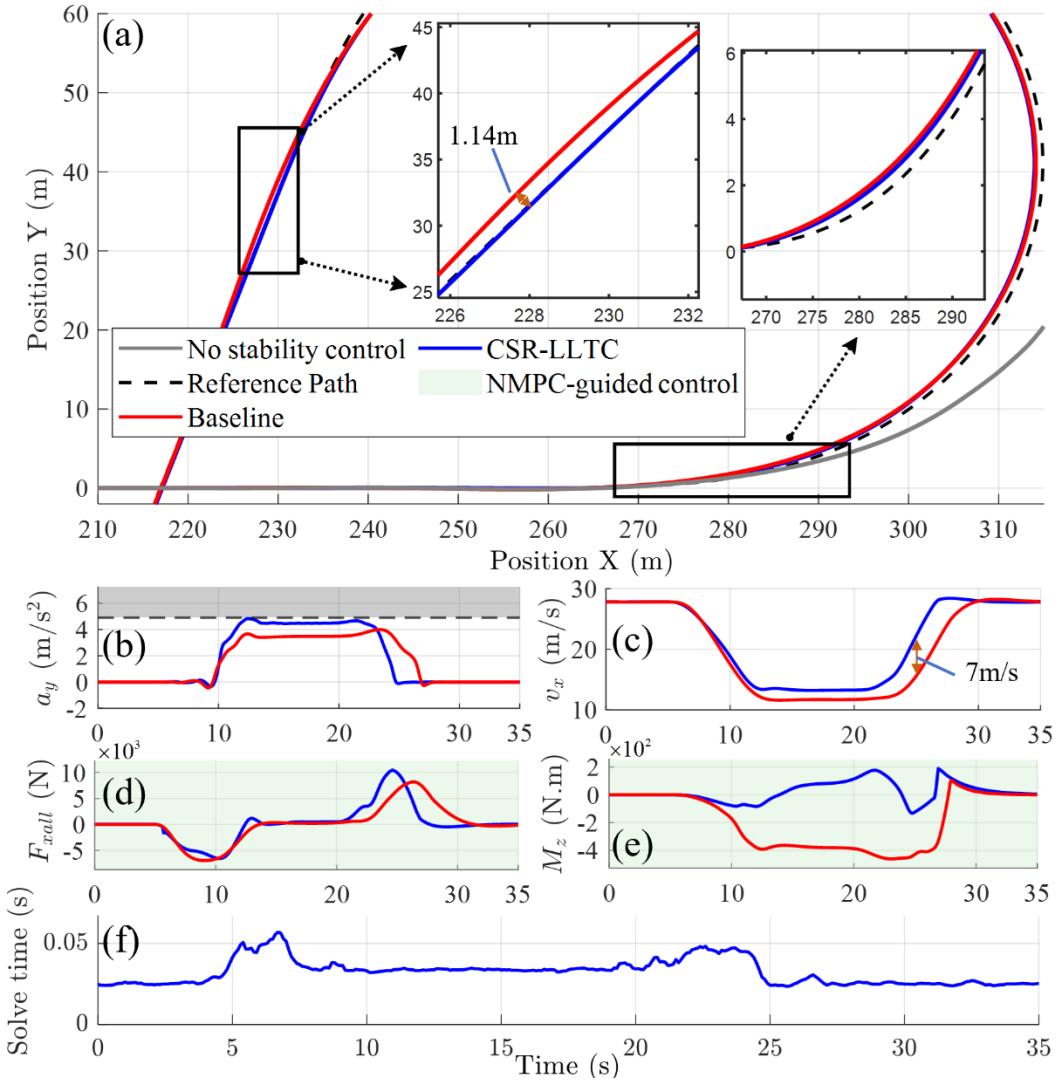
Blue car: proposed
Red car: Baseline
Green car: no stability control

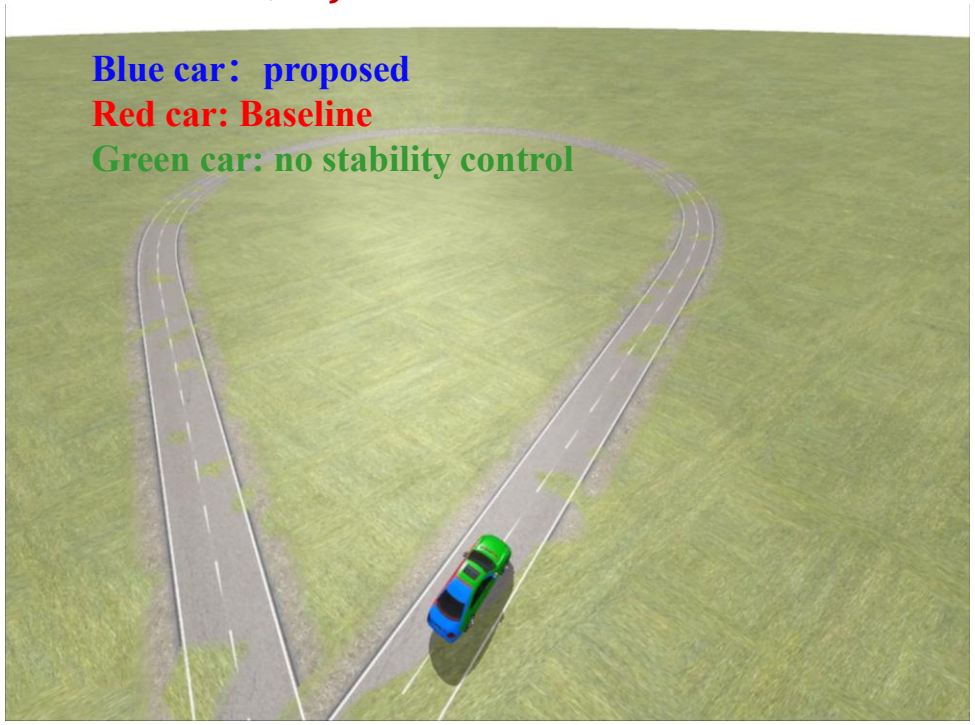


$e_{y,\mathrm{pk}} \downarrow 31.3\%$

Research Experience 2: Coordinated Tracking and Stability Control

Race-Track U-Turn Test under μ=0.5, $v_{x,ref}$=100km/h





$v_{x,\text{avg}} \uparrow 9.3\%$

Related publications:

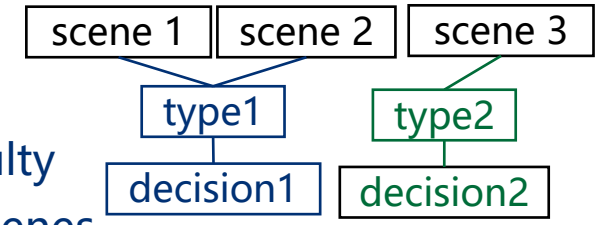
1. **Chengye Wang**, Yu Zhang, Xuepeng Hu, Shaoyang Shi, Jingqi He, Yechen Qin. "Coordinated Tracking and Stability Control of Automated Vehicles at the Limits: A Controlled Stability Region Approach**", 2026 IEEE 29th International Conference on Intelligent Transportation Systems (ITSC)**, Naples, Italy. **(accepted)**
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Research Background 3: Model-data-driven trajectory planning

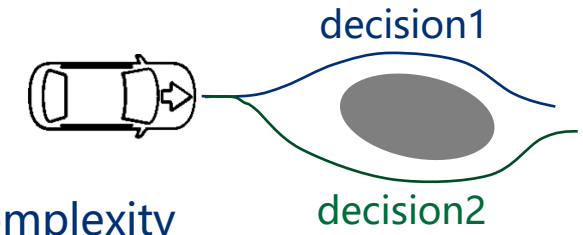
Challenge of Trajectory Planning

Decision-Making Method Research

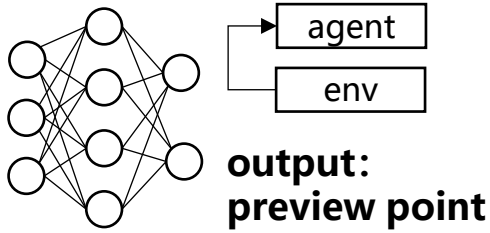
- **Rule-based**
  - Easy for deployment
  - Exhaustive search difficulty and hard for dynamic scenes



- **Planning-based**
  - linked with planning
  - High computational complexity



- **Learning-based**
  - Changing scenarios adaption
  - Poor interpretability



output: preview point

A Framework Integrates Multiple Methods

Trajectory Planning Method Research

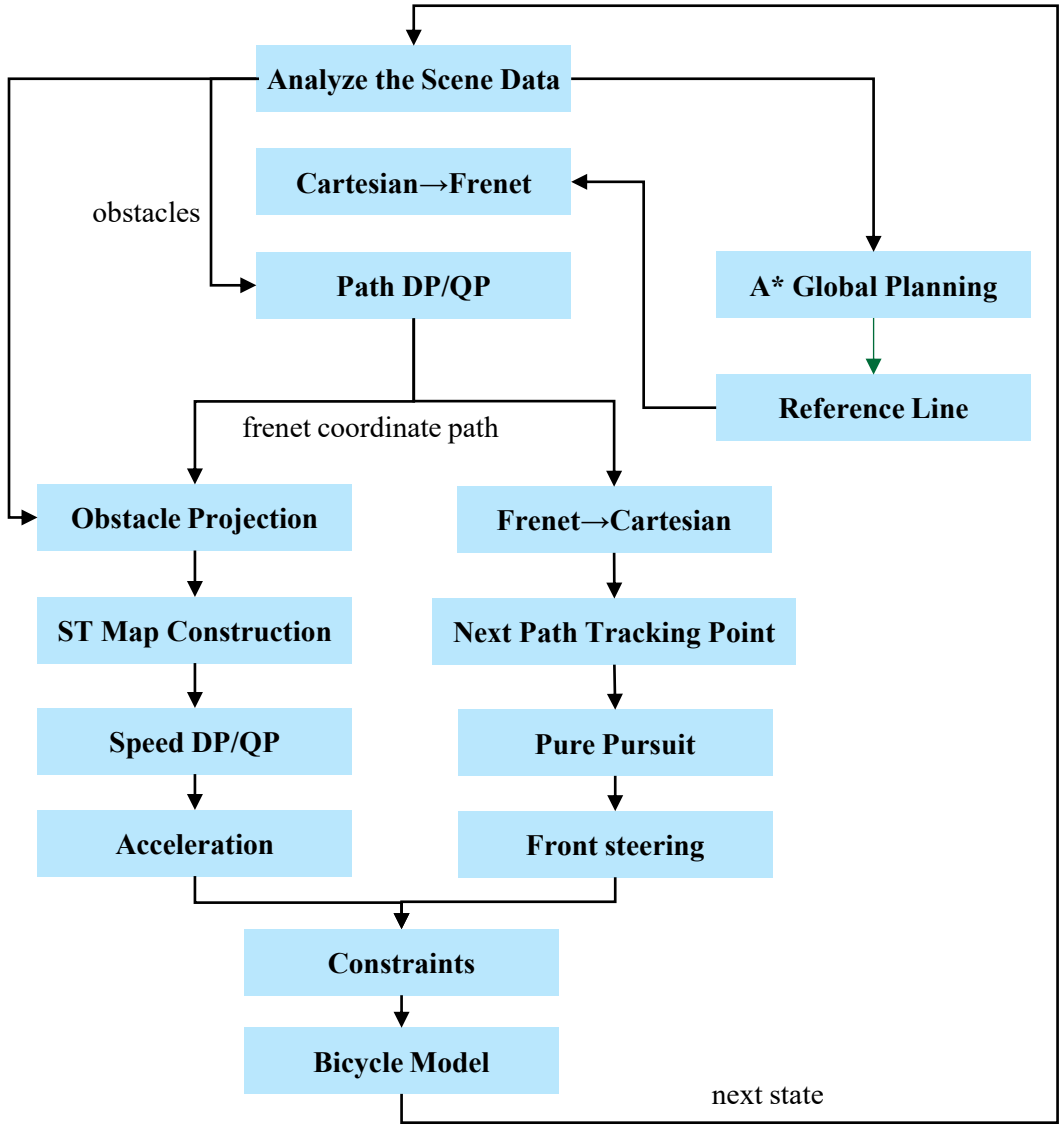
- **Sampling-based**
  - Strong exploration ability
  - Slow obstacle avoidance response
- **Graph search-based**
  - Theoretical completeness
  - Hard to balance the real-time and quality
- **Curve interpolation-based**
  - High efficiency
  - Lack of dynamical feasibility
- **Optimization-based**
  - Advantage in high-quality optimal trajectories.
  - Contradiction between dynamic accuracy and computational efficiency
- **Learning-based**
  - High efficiency
  - Poor interpretability

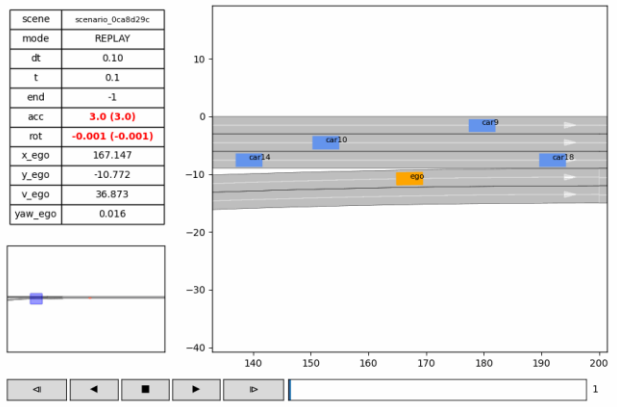
Data-enhanced model optimization method

The Need to Integrate Model-based Approach with the Data-driven Methods

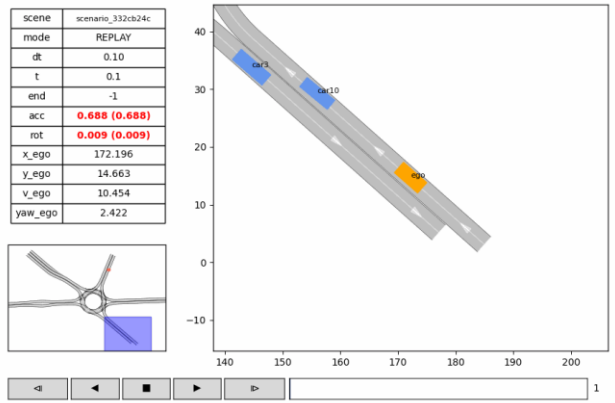
Research Experience 3: Model-data-driven trajectory planning

4th in Onsite Autonomous Driving Algorithm Challenge 2025

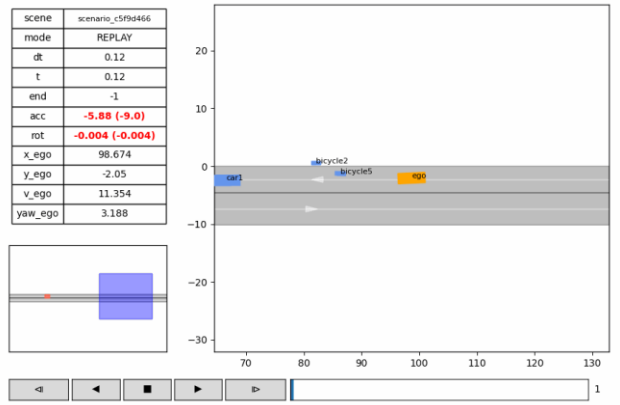




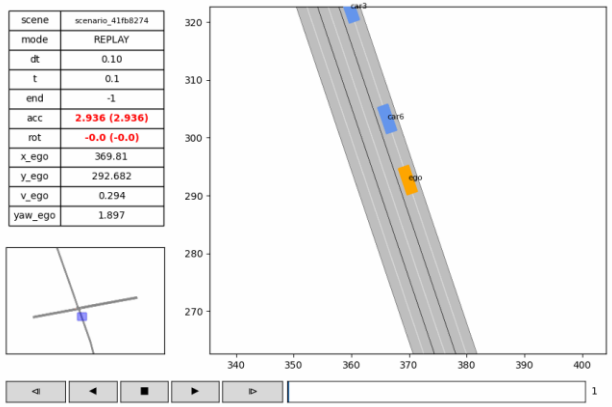
Highway Driving and Highway Merging Scenarios



Urban Roundabout Scenario



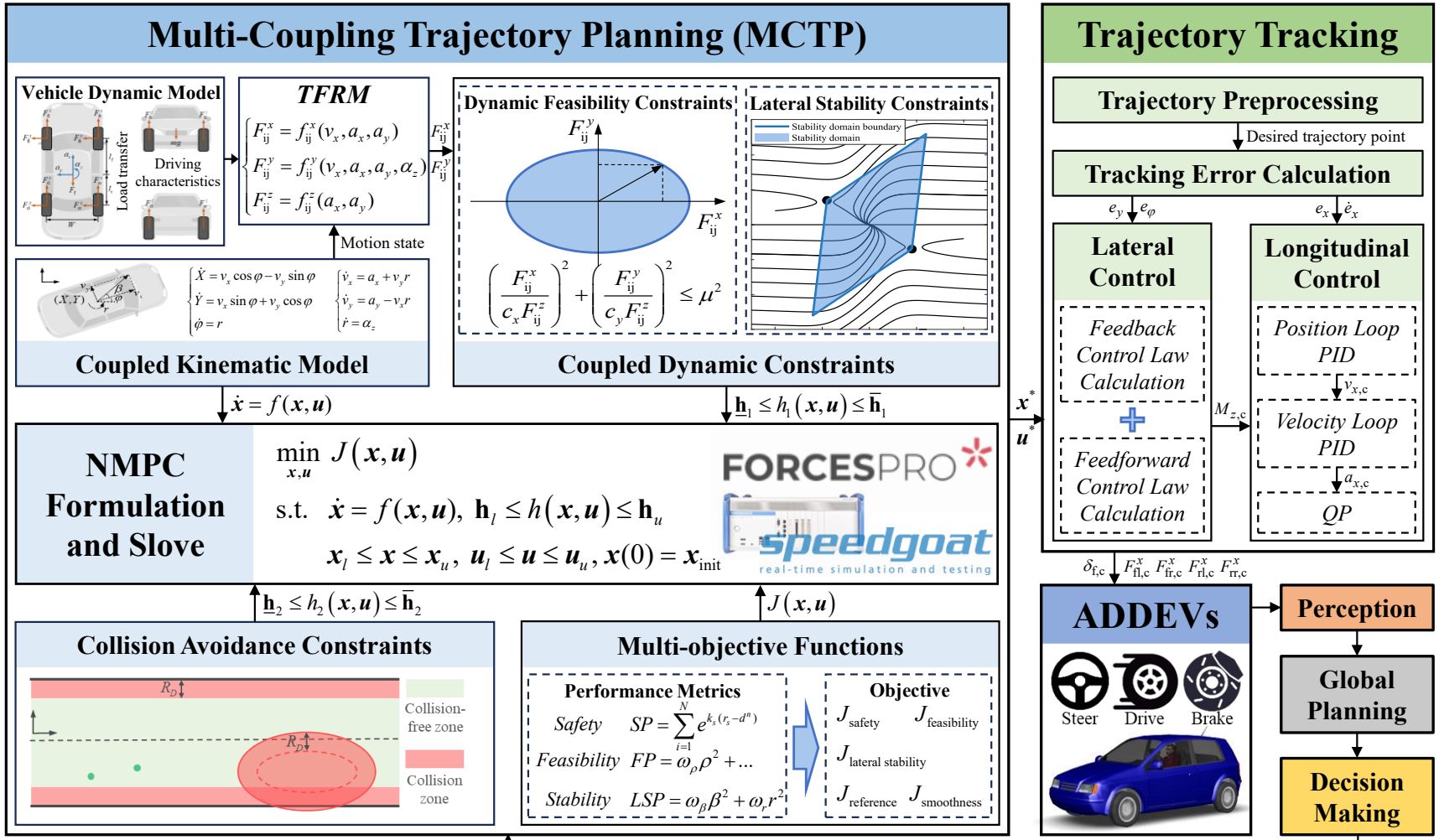
Urban Mixed Traffic Scenario with Bicycles and Pedestrians



Urban Intersection Scenario

Research Experience 3: Model-data-driven trajectory planning

Optimization-based Trajectory Planning Framework



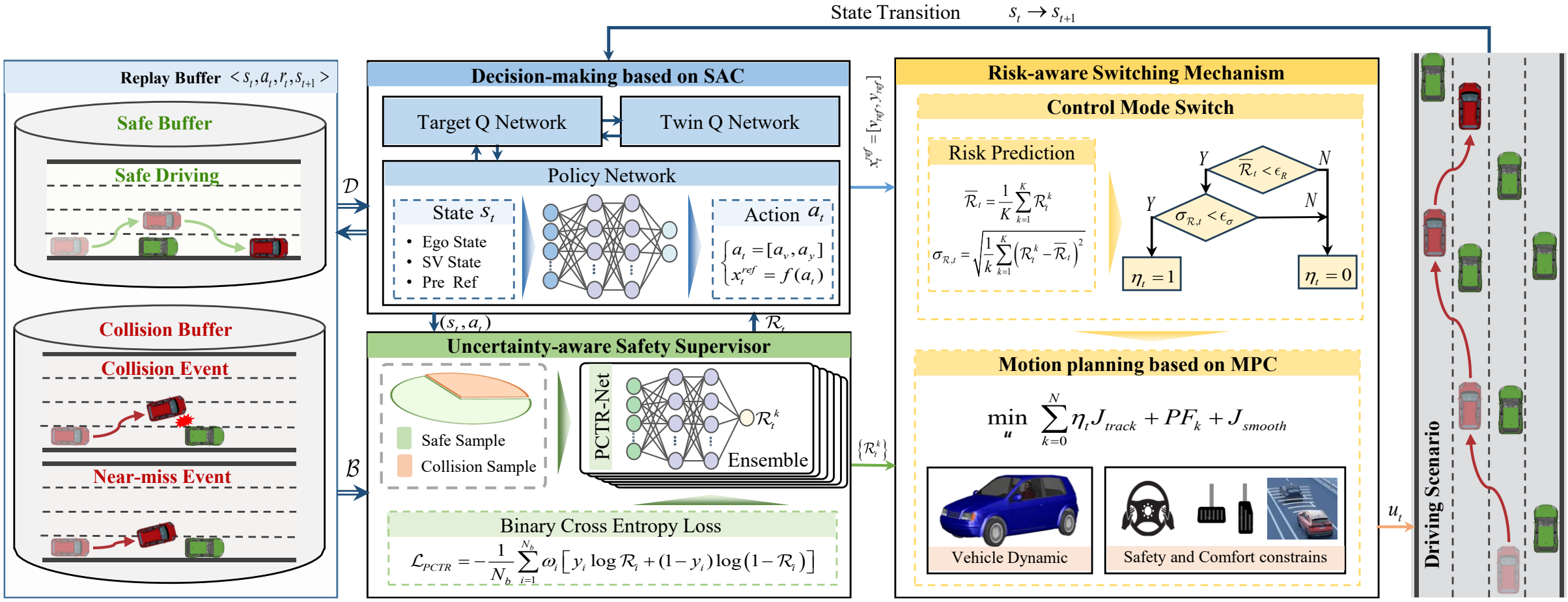
MCTP: A Multi-Coupled Dynamics Trajectory Planning Scheme for Autonomous Driving in Extreme Conditions

Related publications:

1. Xuepeng Hu, Yu Zhang, **Chengye Wang**, Zhenfeng Wang,and Yechen Qin.``MCTP: A Multi-Coupled Dynamics Trajectory Planning Scheme forAutonomous Driving in Extreme Conditions.'' **IEEE Transactions onAutomation Science and Engineering. (accepted, Q2, Top)**

Research Experience 3: Model-data-driven Trajectory Planning

Model-data-driven Framework for Autonomous Driving



Related publications:

1. Shaoyang Shi, Kai Yang, **Chengye Wang**, Dongwei Li, Yu Zhang and Yechen Qin."Self-Evolving Reinforcement Learning Framework for Autonomous Driving via Uncertainty-Aware Collision-Risk Supervision'' **IEEE Transactions on Automation Science and Engineering .(Under review, IF=6.4, JCR Q2, Top)**
2. Shaoyang Shi, Yu Zhang, Kai Yang, **Chengye Wang**, Zhenfeng Wang, and Yechen Qin.``A Risk-Aware Decision Making and Motion Planning Framework forInteractive Autonomous Driving." **2026 IEEE 29th International Conference on Intelligent Transportation Systems (ITSC)**, Naples, Italy. IEEE. **(Accepted)**

Research Experience 3- Model-data-driven Trajectory Planning

Model-data-driven Framework for Autonomous Driving

[redacted]

Self-Evolving Reinforcement Learning Framework
for Autonomous Driving
via Uncertainty-Aware Collision-Risk Supervision

[redacted]

Research Background 4: Distributed Drive Electric Vehicle (DDEV) Platform

Wheel-End Actuation

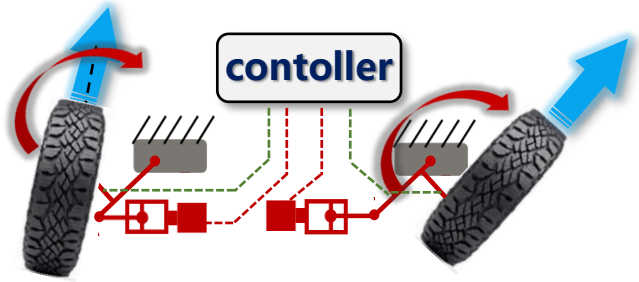


Wheel-end Driving, Braking, and Steering



Power-by-Wire
Ultimate Efficiency

Independent Wheel Control

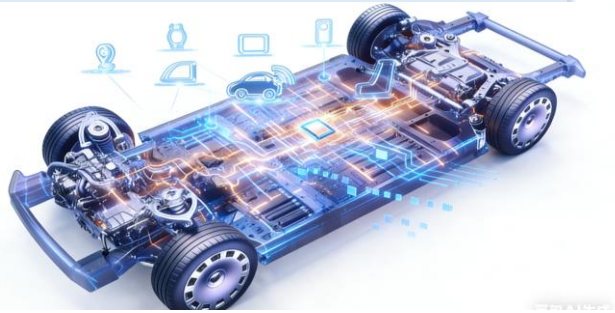


Tire-Road Adhesion → Extremum

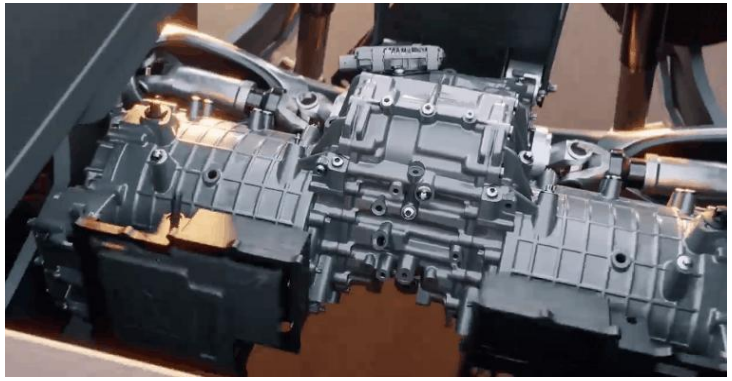


High Control DOFs
Extended Dynamic Boundaries

Software-Defined



AD-Chassis Domain Integration, Customizable Functions

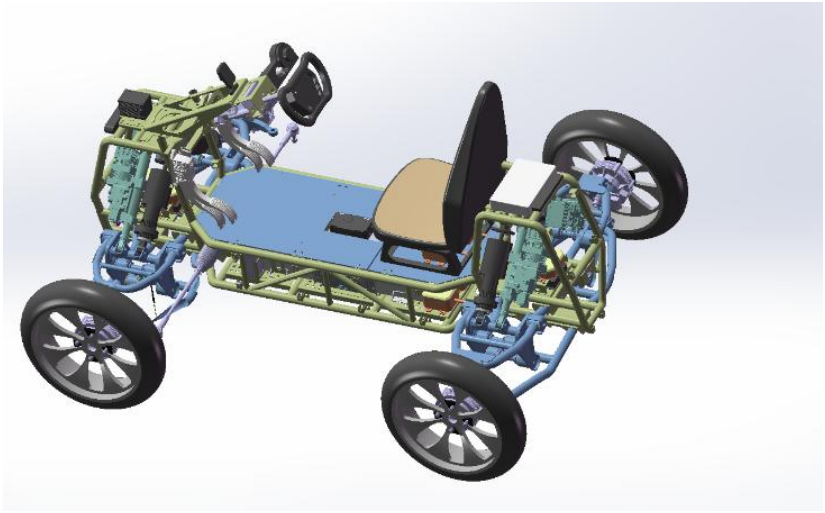


The Optimal Platform for
Autonomous Driving

DDEV Architecture Unleashes the Potential of Vehicle Motion Control

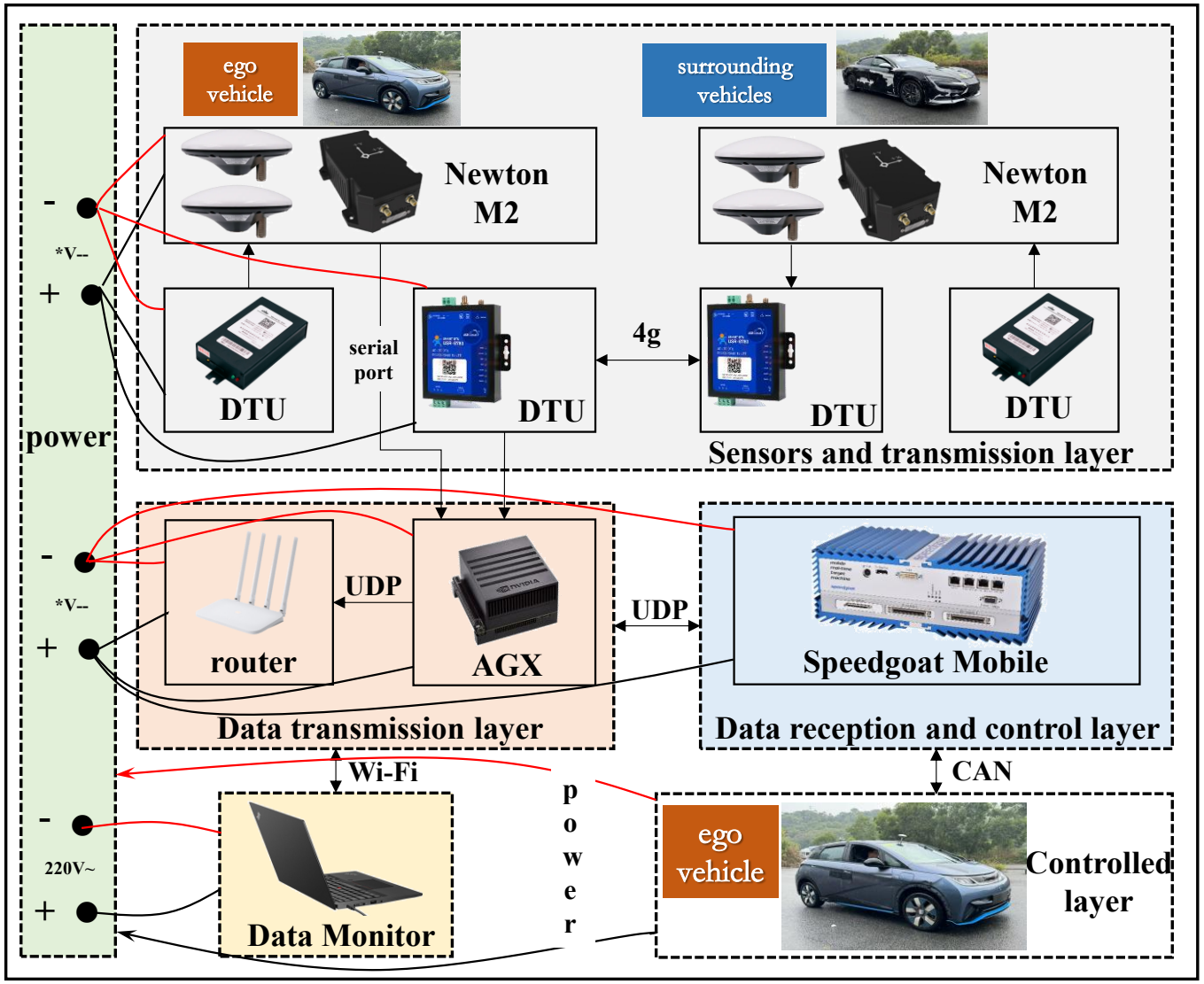
Research Experience 4: Distributed Drive Electric Vehicle (DDEV) Platform

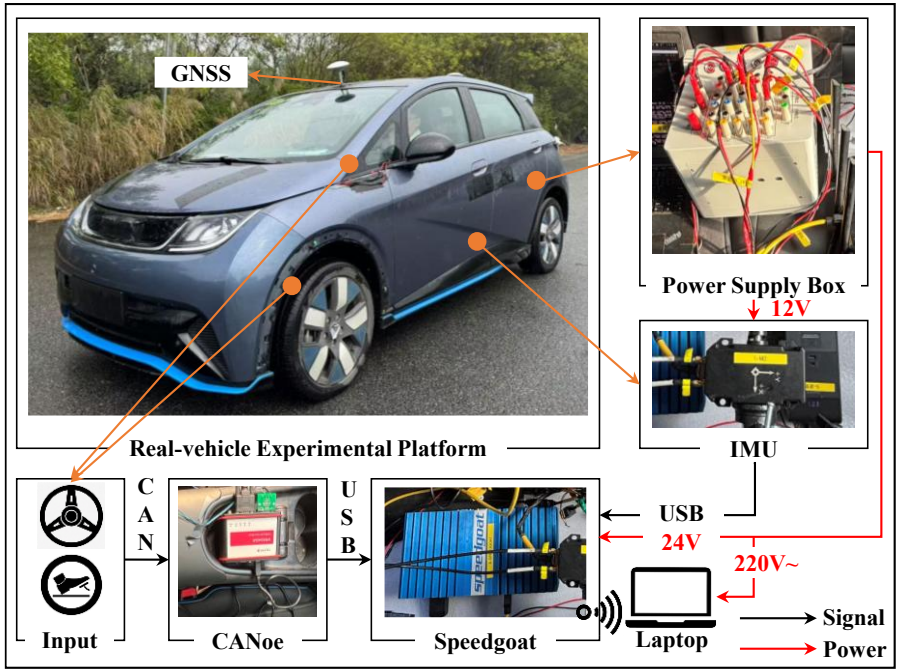




4WD Electric Vehicle

Research Experience 4: BYD Real-vehicle test





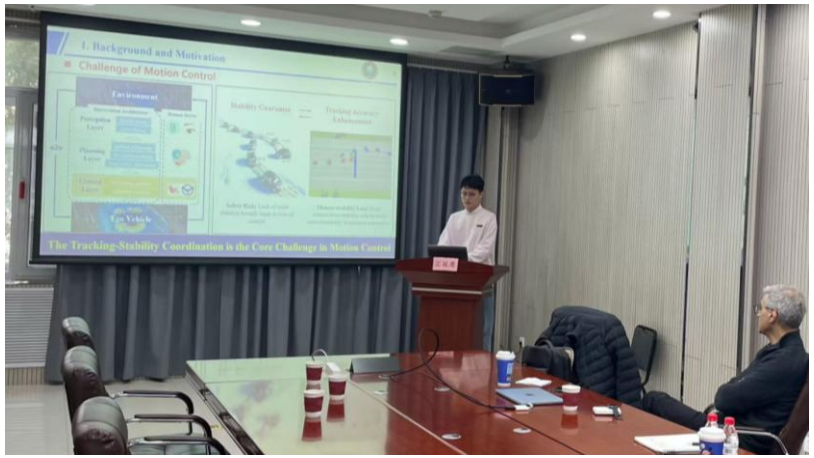
1. Positioning modules and IMU analysis based on Ubuntu/ROS
2. Experimental data communication and hardware debugging

Future Research Interests

- Learning-based MPC framework under extreme conditions (low adhesion, high speed)
- Model-data-driven decision-making and trajectory planning for autonomous vehicles.



Talk, SAE 2025 Intelligent and Connected Vehicles Symposium, Chongqing, China.



Presentation on behalf our lab to Prof. Amir Khajepour, University of Waterloo, Canada.

September 15th-18th
IEEE ITSC 2026
Napoli, Italy

Presentation coming soon. See you in ITSC 2026.

Thanks!

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Beijing, China