

抢先整体协同道路交通系统

Preemptive Holistic Collaborative Road Transportation System



长安大学
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从您所在之处，到您神往之地，
安全、舒适、快捷，
抢先整体协同道路交通系统，
为在每一条道路上前进的每一个您量身
定制每一秒的美好体验！

Preemptive Holistic
Collaborative
Road Transportation System

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01

背景

PART. 01

背景

传统的人工驾驶和单车智能驾驶系统在准确、及时地获取周围车辆的当前驾驶状态和意图方面面临着重大挑战。



难以获得驾驶意图

单辆车无法准确及时地获取其他车辆的驾驶意图和环境状况。

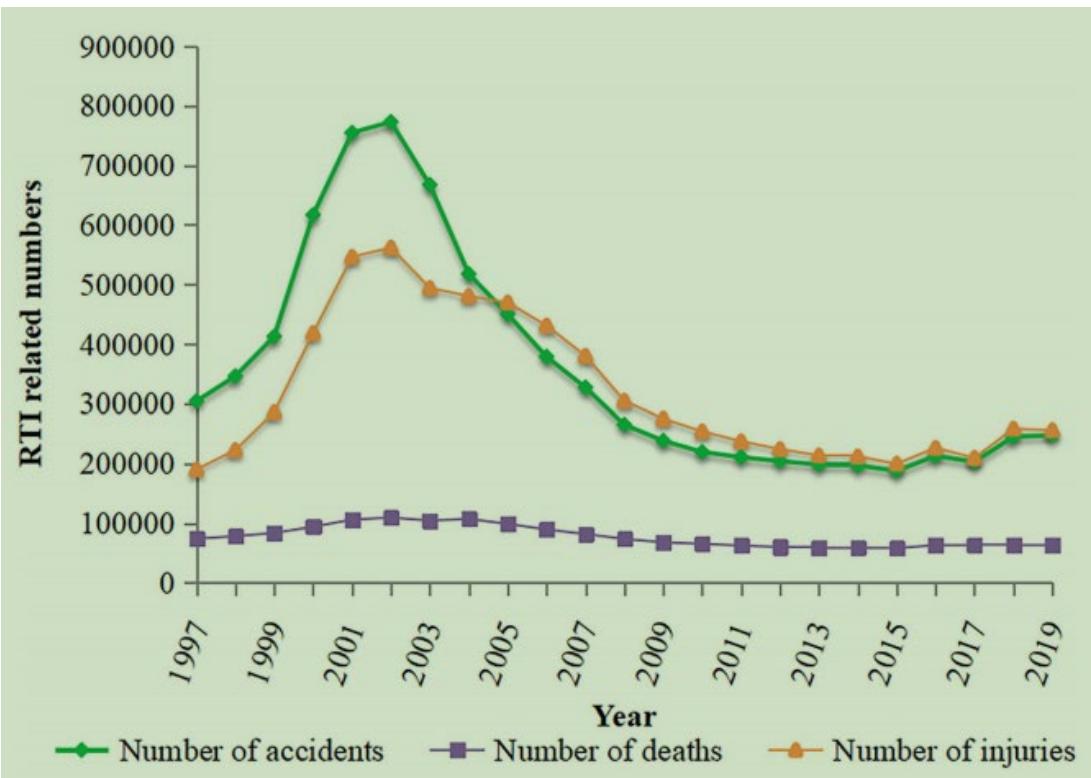


道路交通伤害 (RTIs)

世界卫生组织报告，每年约有135万人死于RTI（世界卫生组织，2018）。



背景



1997-2019年中国道路交通伤害人数趋势

2019年中国RTI，其中，造成25万人受伤，24万起交通事故，8万人死亡，

根据1997年至2016年RTI的研究数据 (Ye等人, 2019)

背景



陕西柞水高速公路



广州南沙沁心大桥



广东梅大高速

交通基础设施失效

基础设施突然失效，驾驶员难以及时做出反应以应对突发意外，导致后续多起交通事故。

车速交通堵塞

车辆一直处于堵塞状态，导致通行变成及其痛苦的问题，城市通行效率降低。

需要更安全、高效的道路交通系统



抢先整体协同道路交通系统

Preemptive Holistic Collaborative Road Transportation System 【1-5】



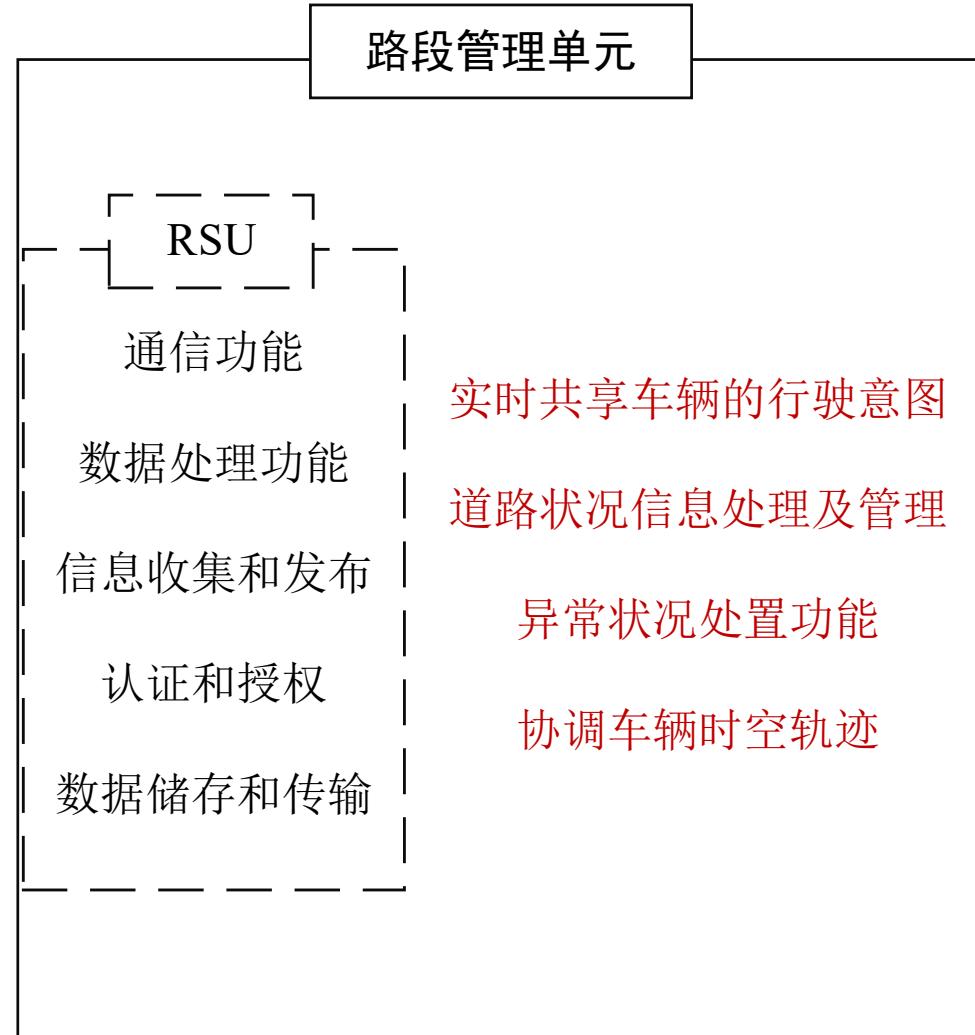
02

整体视角

PART. 02

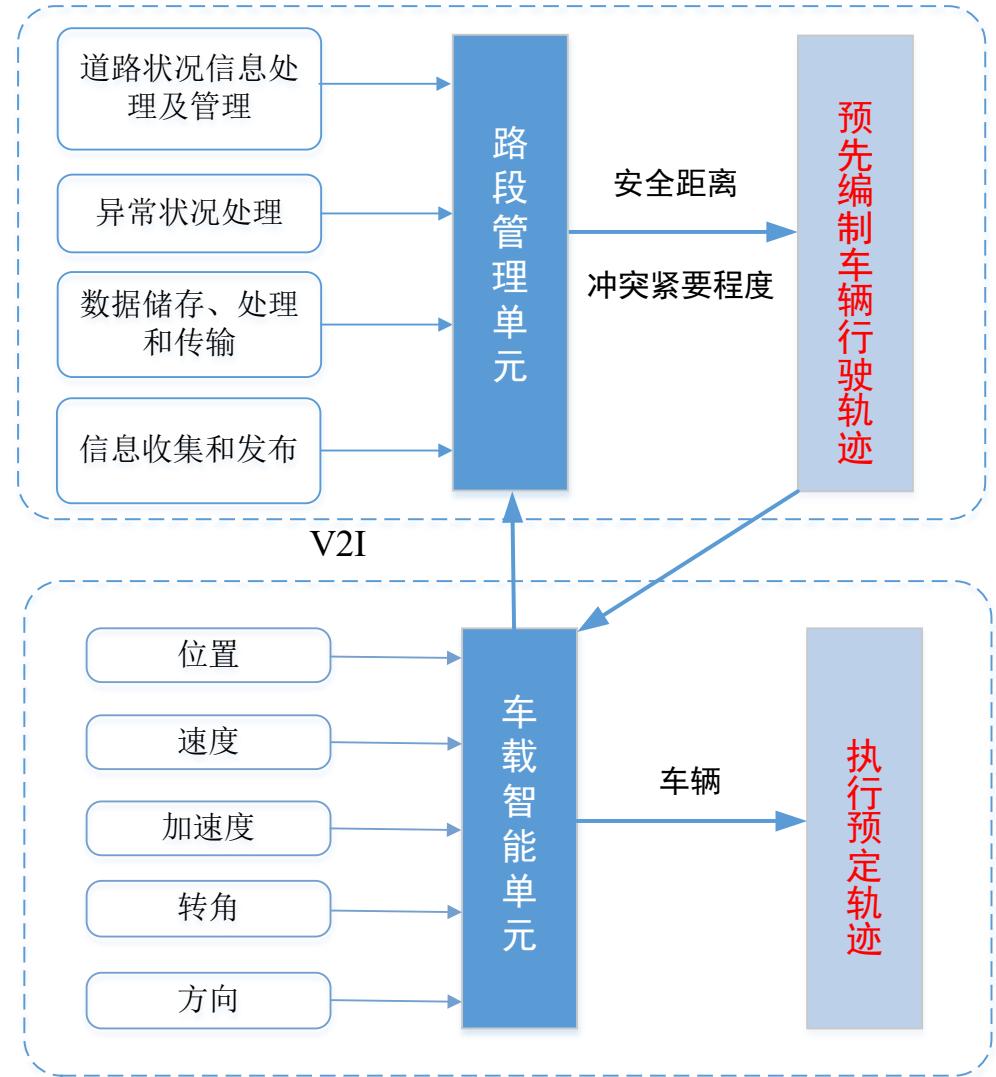
信息共享整体视图

提出了路 段 管 理 单 元 (Road Section Manager Unit, RSMU)。在传统路侧单元的核心功能 的 基础上进行了一系列的功能扩展与优化，以适应日益复杂的智能交通系统需求。



路段管理单元功能组成

抢先整体协同框架



车路抢先整体协同基本框架



预期效果

提高交通效率

缓解拥堵

提升安全性

交通流稳定性

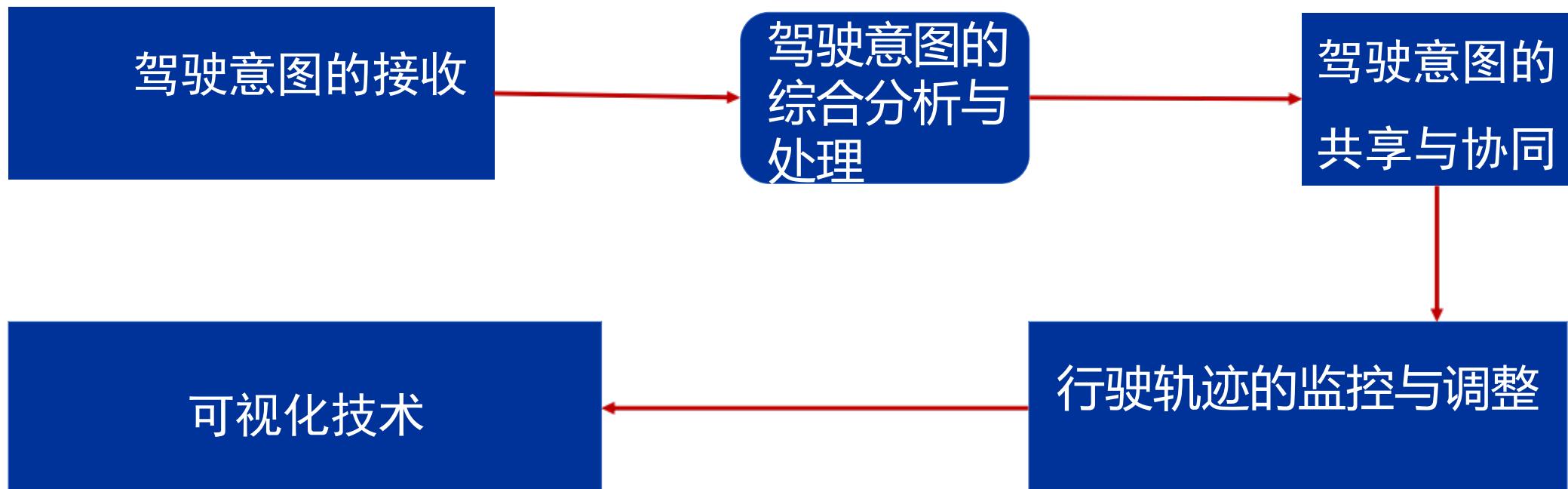
燃油效率

乘客舒适性

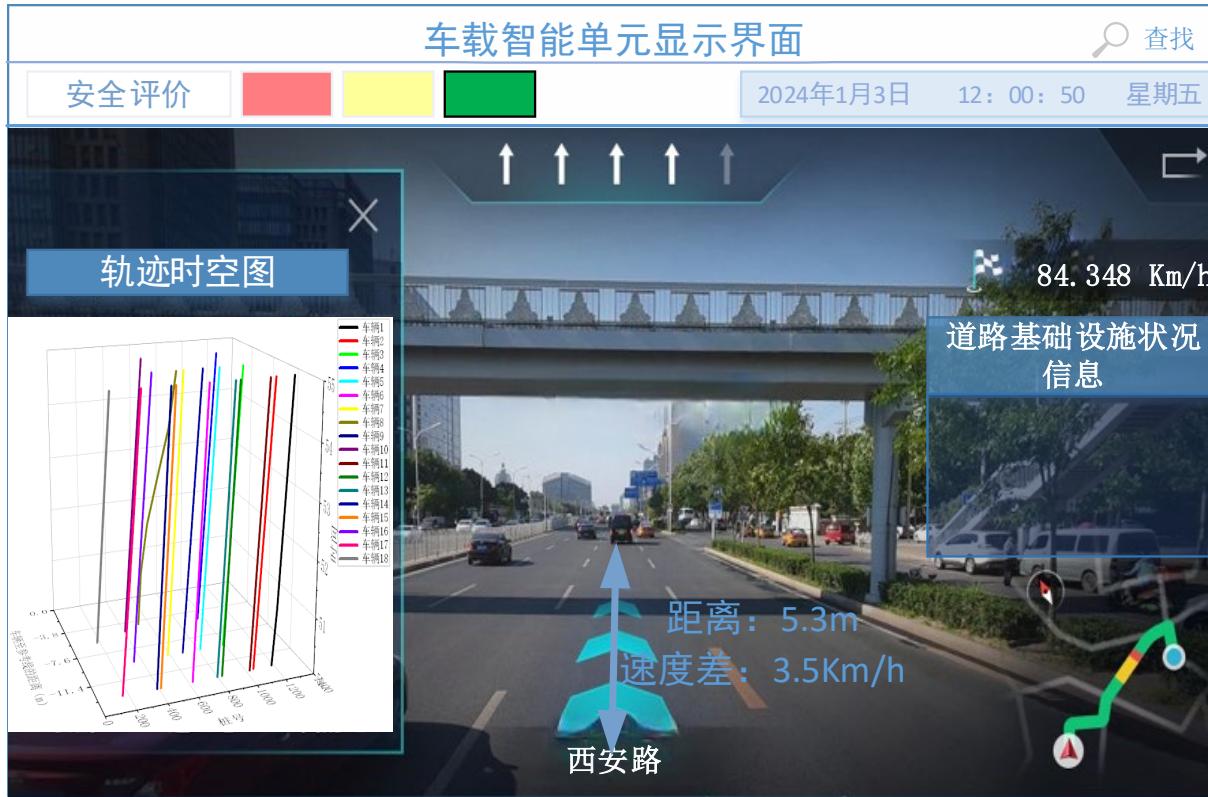
实时共享车辆的驾驶意图：

车载智能单元通过传感器和其他设备实时采集驾驶员的驾驶意图，如超车、变道、停车等。

技术实现： 车载智能单元将行驶意图共享至路段管理单元



抢先整体协同视角



车载智能单元显示界面示例图

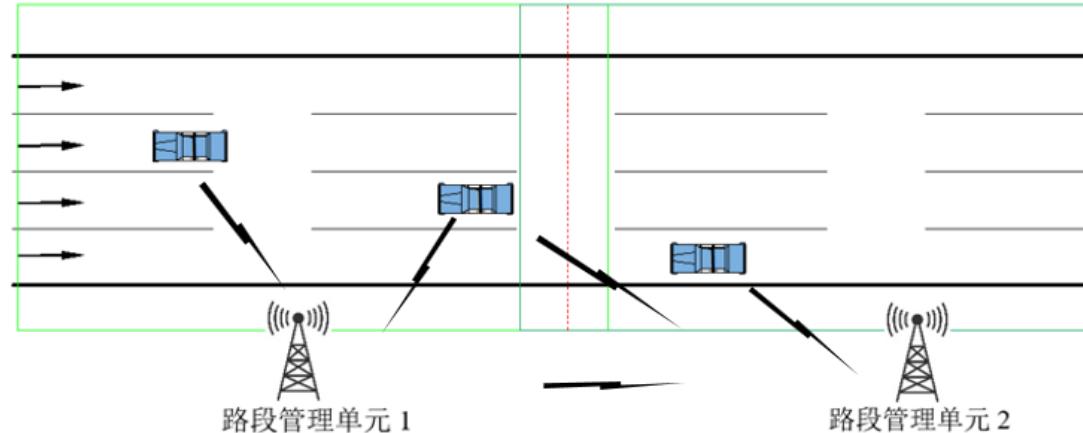
左侧部分：是轨迹时空图

界面的右上部：是本车当前行驶信息的集中展示区

界面的中央：是以本车为第一视角的运行状态图

右下角设置了道路基础设施信息栏

共享机制实现机理

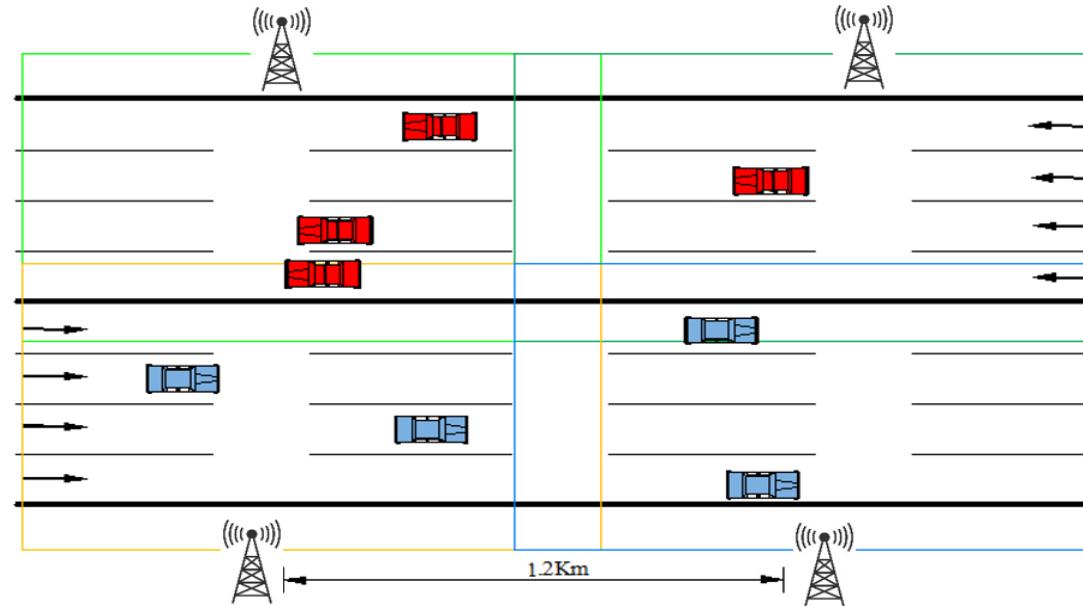


高速公路主线的路段管理单元布设方式

在保证车载智能单元和路段管理单元时间同步的基础之上，在路段管理单元和路段管理单元之间实现信息实时共享，从而实现邻近区域内车辆之间的信息实时共享。

当即使某个路段出现异常，能够预先编制或调整相关车辆轨迹，在实现车路协同的同时避免后续不良影响。

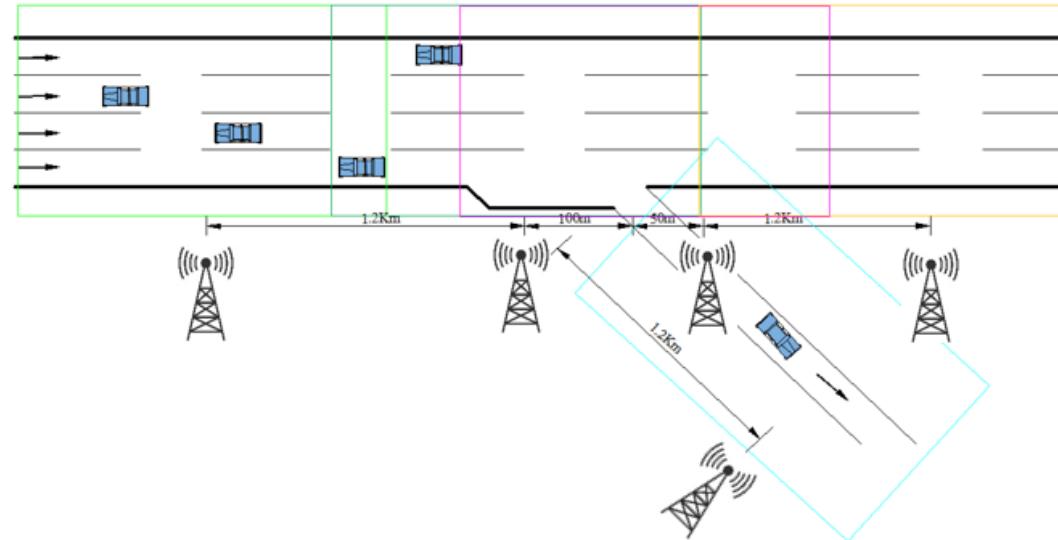
共享机制实现关键技术



高速公路主路的路段管理单元布设方式

对于高速公路主路，行车流的方向一般为两个，车流量也比较大。为了便于路段管理单元的管理，在车道两侧都设置路段管理单元，分别管理不同行驶方向的车辆，如图所示，两路段管理单元之间距离在1.2 km左右，部署高度确保无遮挡即可。

共享机制实现关键技术



高速公路匝道出口的路段管理单元布设方式

对于交通流复杂的高速公路匝道出口，驶出前的一段距离内车辆行驶状态和运行轨迹变化较多，此区域对于车辆行驶存在巨大的安全隐患，可以在驶出点前100m及驶出点后50m等处部署路段管理单元节点。

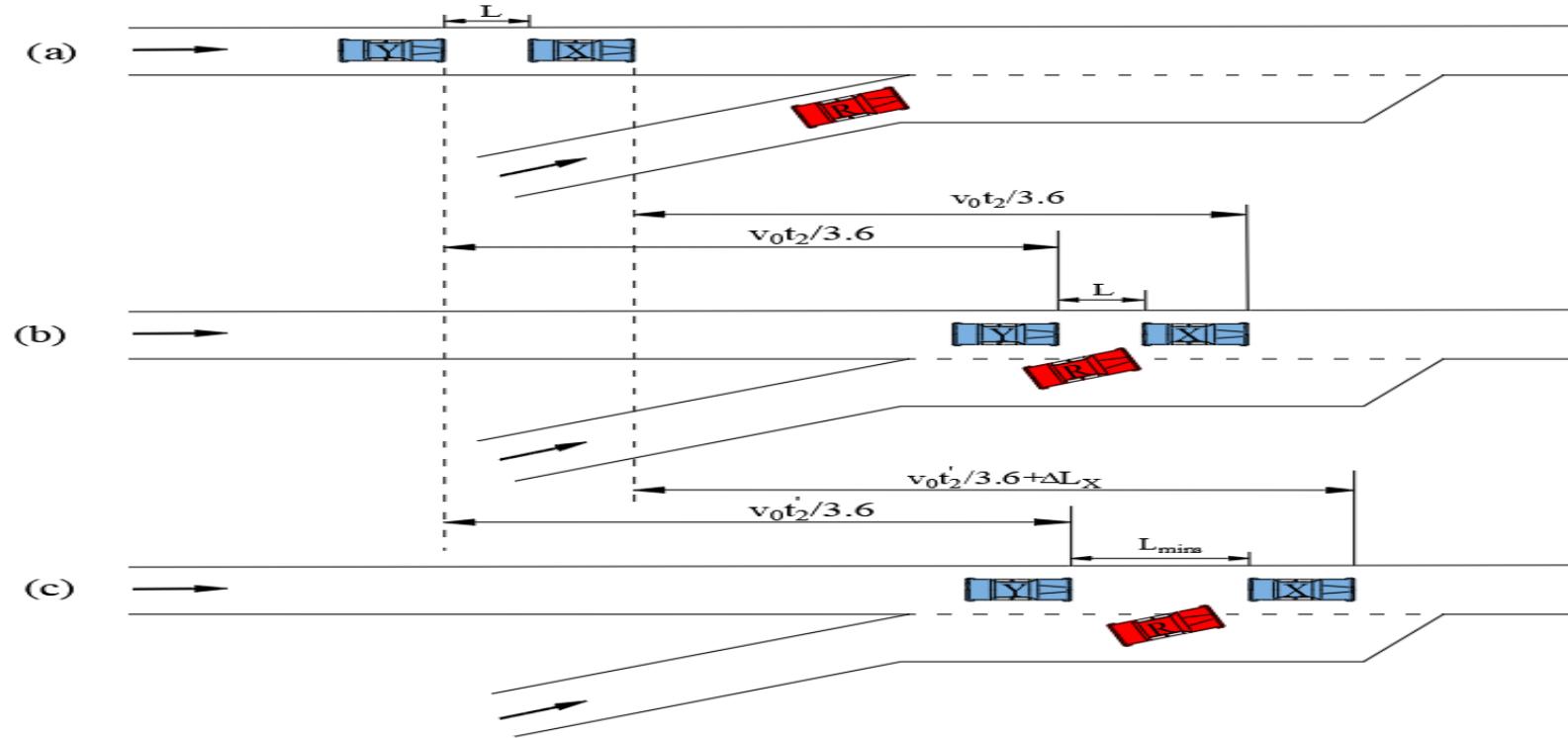


03

抢先整体协同效果

PART. 03

时空轨迹调整



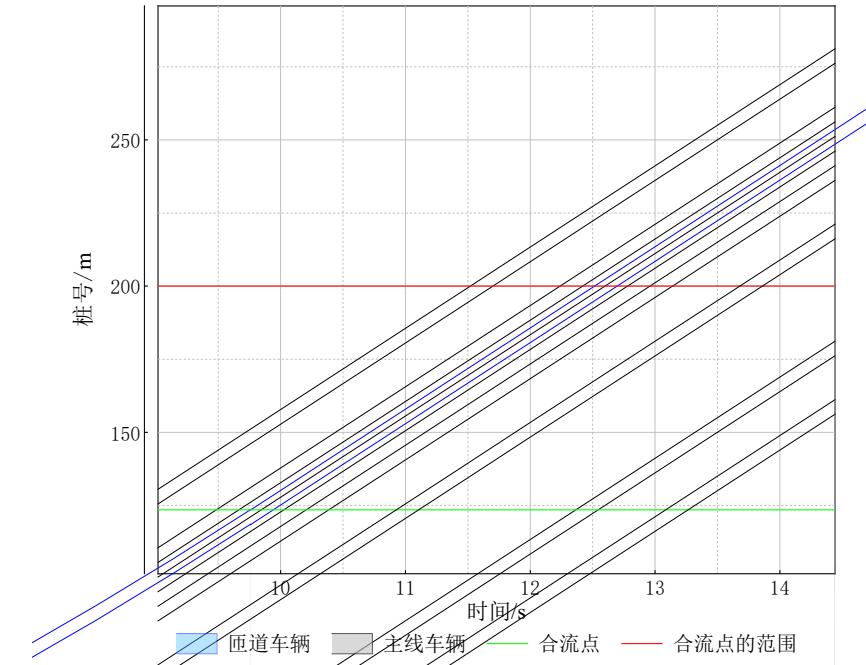
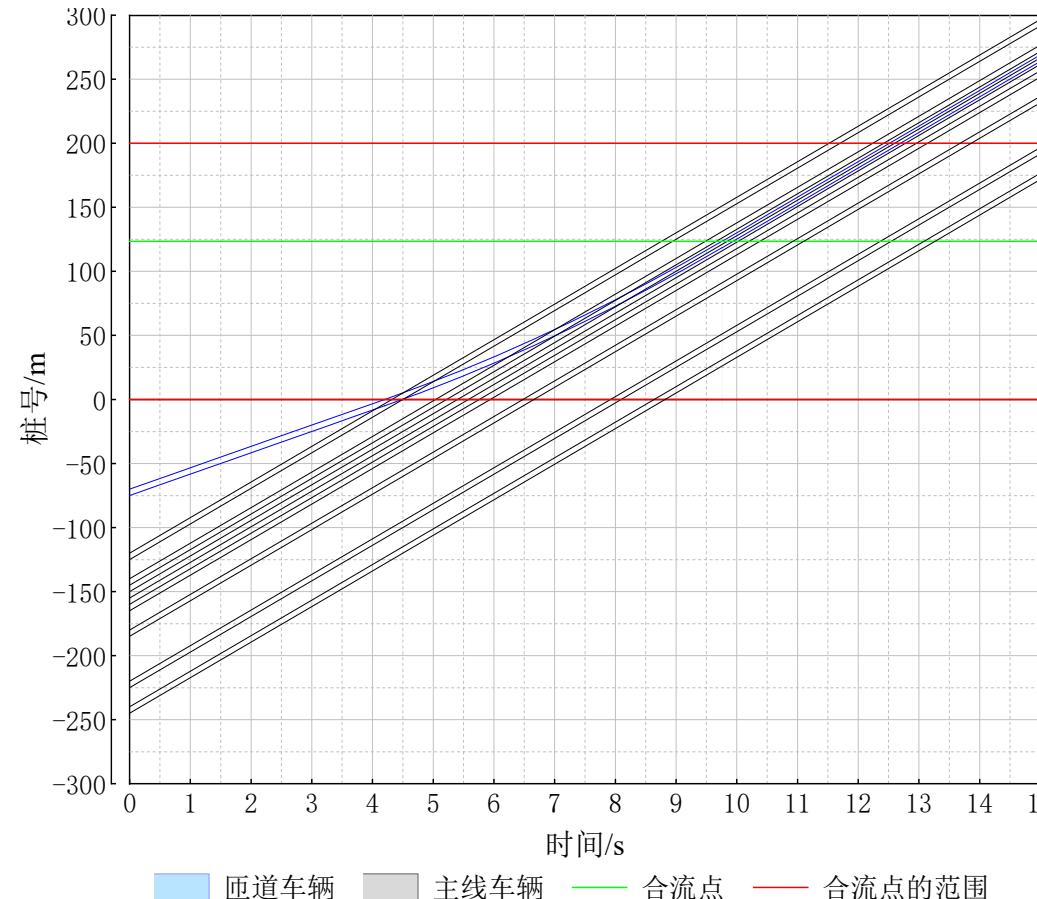
以高速公路为例，建立抢先整体协同控制方法。

图(a)为匝道车辆到达匝道末端时各车辆的位置示意图

图(b)为调整之前匝道车辆并入主线时各车辆的位置示意图

图(c)为调整之后匝道车辆并入主线时各车辆的位置示意图

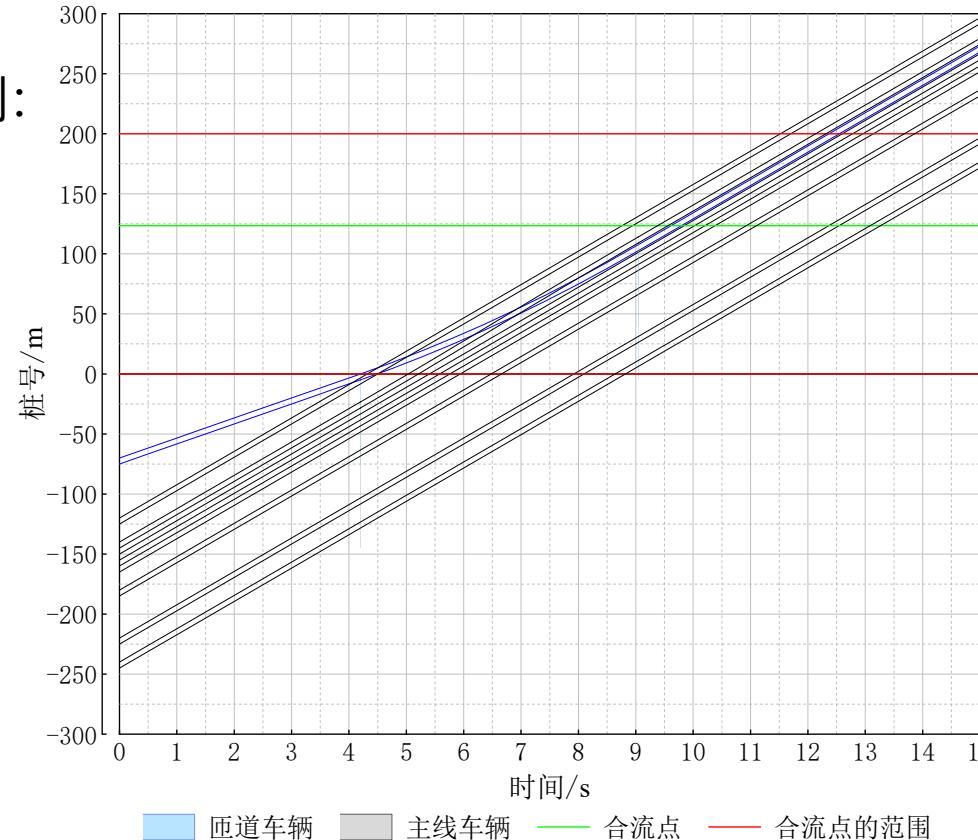
时空轨迹调整



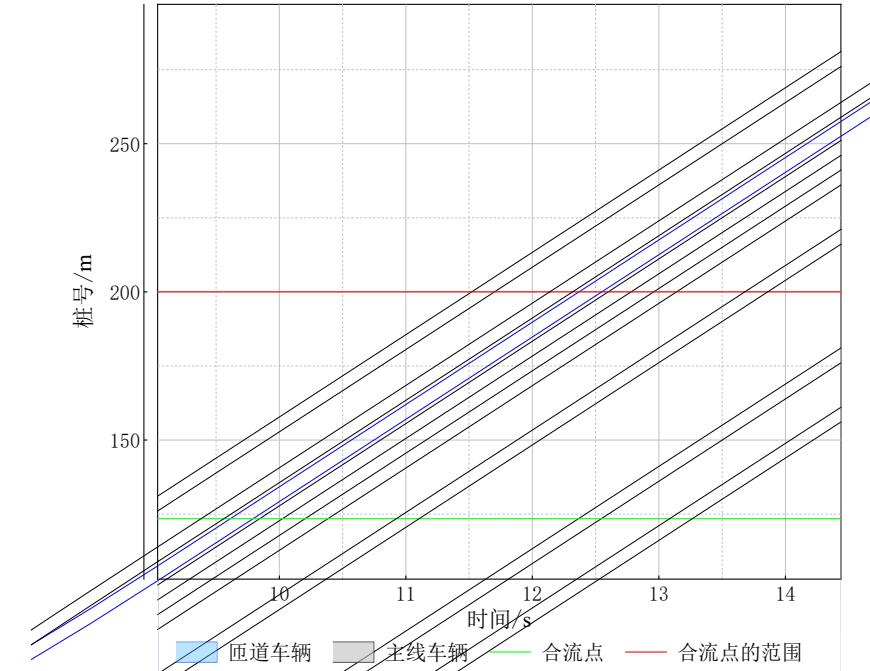
调整前车辆碰撞时空图合流点后的局部放大图

时空轨迹调整

例：



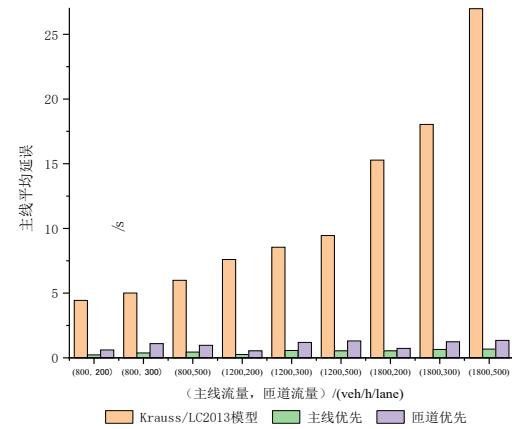
调整后车辆碰撞时空图



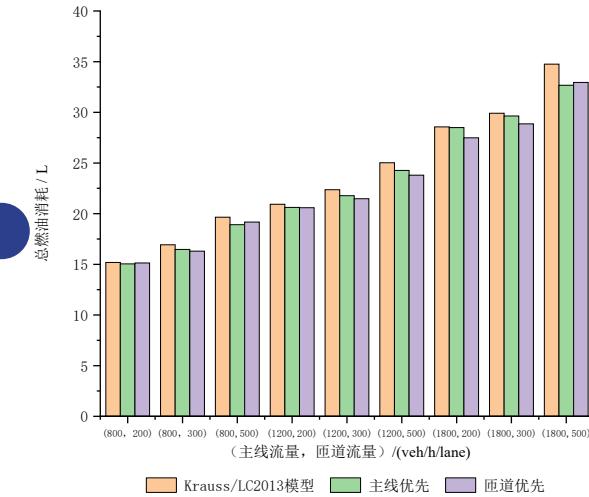
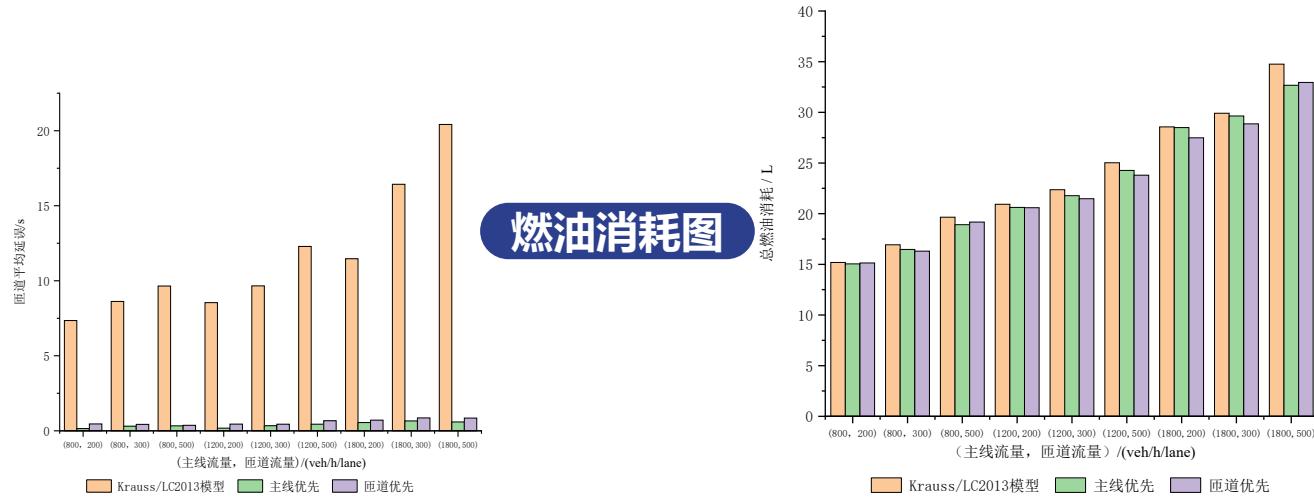
调整后车辆碰撞时空图合流点后的局部放大图

性能评价

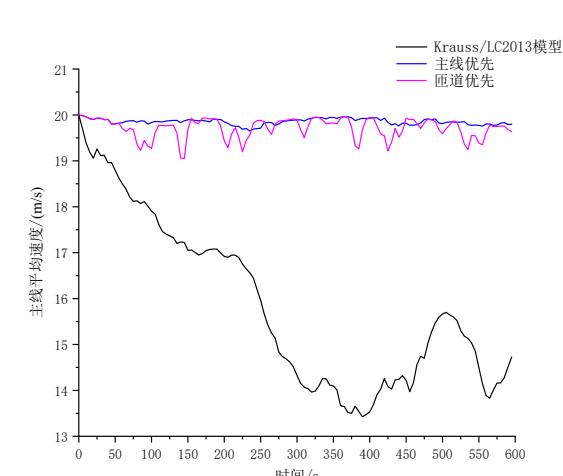
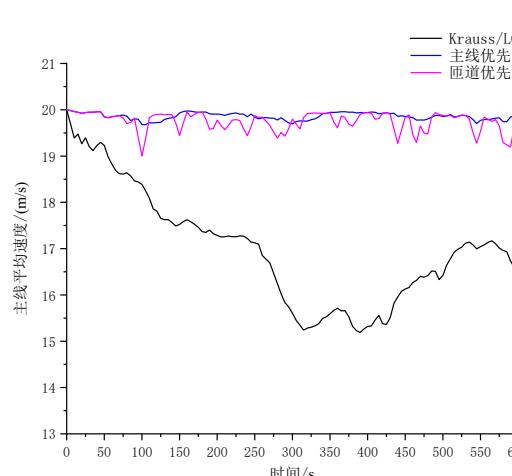
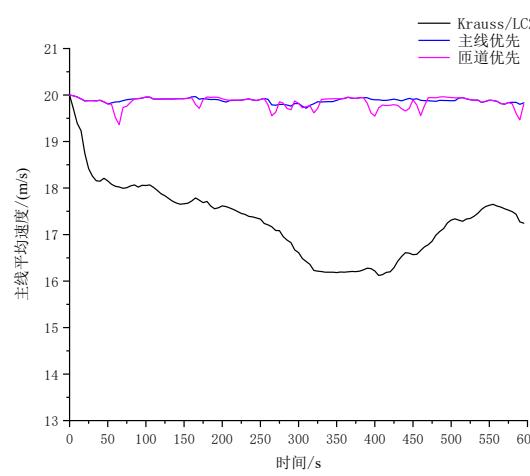
平均延误图



燃油消耗图



平均速度图





04

结论

PART. 04

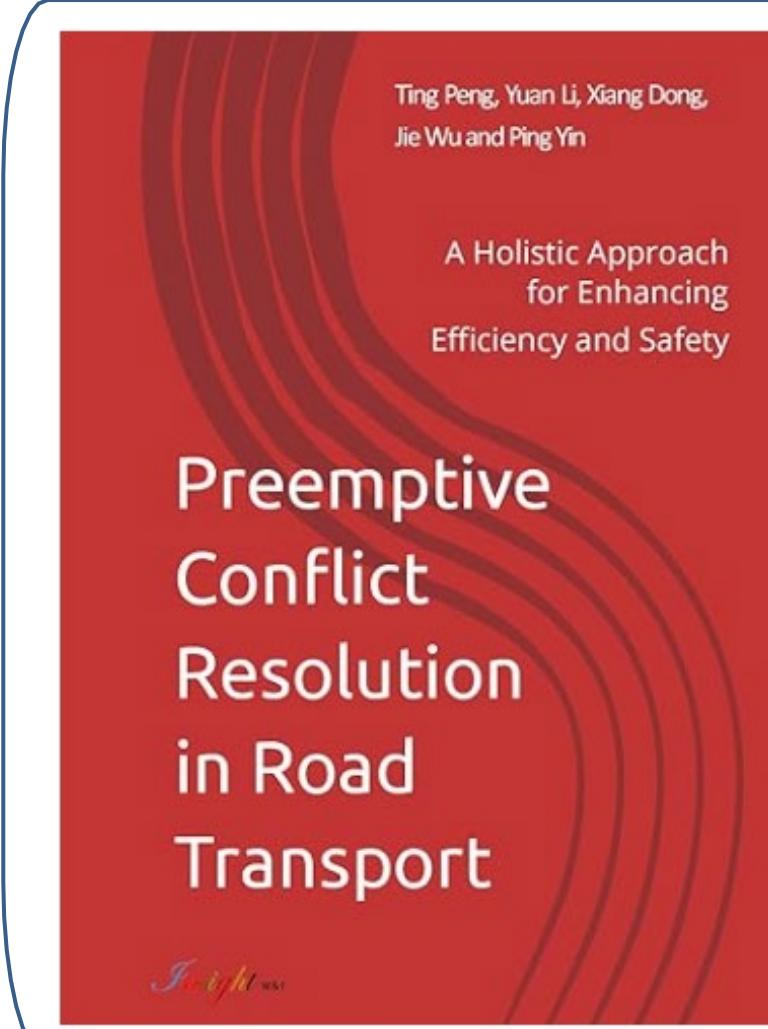
结论

- 抢先依据所有车辆的意图预先编制时空轨迹，提前消除了车辆之间的冲突。
- 当交通量大时车辆平均延误时间减少可达97.96%，燃料消耗减少可达6.01%。
- 与现有策略^[5]相比，道路通行能力可提高4倍甚至更高。
- 根据美国的全国机动车事故原因调查报告^[6] 关于交通事故关键原因的统计结果，采用抢先整体协同可以消除90%以上的交通事故。

参考文献

1. Peng, Ting, et al. "Preemptive Holistic Collaborative System and Its Application in Road Transportation." arXiv preprint arXiv:2411.01918 (2024).
2. Tao, Li, et al. "Holistic view of the road transportation system based on real-time data sharing mechanism." arXiv preprint arXiv:2407.03187 (2024).
3. X. Xu et al., "Spatio-temporal Cooperative Control Method of Highway Ramp Merge Based on Vehicle-road Coordination," 2024 12th International Conference on Traffic and Logistic Engineering (ICTLE), Macau, China, 2024, pp. 93-98, doi: 10.1109/ICTLE62418.2024.10703891.
4. Peng, Ting, et al. "Optimizing Highway Ramp Merge Safety and Efficiency via Spatio-Temporal Cooperative Control and Vehicle-Road Coordination." arXiv preprint arXiv:2408.08121 (2024).
5. Peng, Ting, et al. "Preemptive Conflict Resolution in Road Transport: A Holistic Approach for Enhancing Efficiency and Safety." eBook ISBN: ISBN 979-8-9914520-0-7.
6. X. Y. Wu and S. D. Fu, "Research on Safe Following Distance on an Expressway Based on Braking Process Analysis," APPLIED SCIENCES-BASEL, vol. 13, no. 2, JAN 2023, Art no. 1110, doi: 10.3390/app13021110.
7. N. H. T. S. Administration, "National motor vehicle crash causation survey: Report to congress," National Highway Traffic Safety Administration Technical Report DOT HS, vol. 811, p. 059, 2008.

参考文献



Preemptive Conflict Resolution in Road Transport: A Holistic Approach for Enhancing Efficiency and Safety

Unlock the Future of Road Safety and Efficiency with SERTS

In a world where traditional manual driving and single-vehicle intelligent systems fall short, this groundbreaking book introduces the Safe and Efficient Road Transportation System (SERTS). Addressing the critical challenges of real-time driving status acquisition and infrastructure assessment, SERTS offers two innovative solutions. The first is a real-time information-sharing mechanism that provides a comprehensive spatiotemporal view of road traffic, enabling instant access to the driving intentions of nearby vehicles and the status of road infrastructure. The second solution involves a spatiotemporal coordinated approach, where the Road Section Management Unit (RSMU) pre-plans vehicle trajectories, executed by Vehicle Intelligent Units (VIUs) to prevent conflicts. This book also presents a novel method for calculating safe distances and assessing collision urgency. Through validated control strategies for expressway ramp merging, SERTS promises to revolutionize road traffic efficiency and safety. Dive into this essential read to explore how SERTS can transform our transportation systems and save lives.

代码示例

抢先整体协同道路交通系统 源代码示例

The screenshot shows a GitHub repository page for 'PreemptiveHolisticCollaborativeSystem'. The repository has been active for 4 days and contains several files:

- BaseLine
- Krauss_LC2013
- TryPreemptiveHolisticCollaborativeSystem
- HowtoRun.txt
- README.md
- requirements.txt

The README file contains the following text:

Preemptive Holistic Collaborative System and Its Application in Road Transportation

Numerous real-world systems, including manufacturing processes, supply chains, and robotic systems, involve multiple independent entities with diverse objectives. The potential for conflicts arises from the inability of these entities to accurately predict and anticipate each other's actions. To address this challenge, we propose the Preemptive Holistic Collaborative System (PHCS) framework. By enabling information sharing and collaborative planning among independent entities, the PHCS facilitates the preemptive resolution of potential conflicts. We apply the PHCS framework to the specific context of road transportation, resulting in the Preemptive Holistic Collaborative Road Transportation System (PHCRTS). This system leverages shared driving intentions and pre-planned trajectories to optimize traffic flow and enhance safety. Simulation experiments in a two-lane merging scenario demonstrate the effectiveness of PHCRTS, reducing vehicle time delays by 90%, increasing traffic capacity by 300%, and eliminating accidents. The PHCS framework offers a promising approach to optimize the performance and safety of complex systems with multiple independent entities.

抢先整体协同系统及其在道路交通中的应用

许多现实世界的系统，包括制造过程、供应链和机器人系统，都涉及多个具有不同目标的独立实体。由于这些实体无法准确预测和预料彼此的行为，因此存在潜在的冲突。为了解决这一挑战，我们提出了抢先整体协同系统（PHCS）框架。通过启用独立实体之间的信息共享和协作规划，PHCS有助于提前解决潜在冲突。我们将PHCS框架应用于道路交通的特定背景，形成了抢先整体协同道路交通系统（PHCRTS）。该系统利用共享的驾驶意图和预先规划的轨迹来优化交通流并提高安全性。在双车道合并场景中的模拟实验表明，PHCRTS的有效性显著，可减少车辆延误90%，增加交通容量300%，并消除事故。PHCS框架为优化复杂系统中多个独立实体的性能和安全性提供了一种有前景的方法。

Repository statistics:

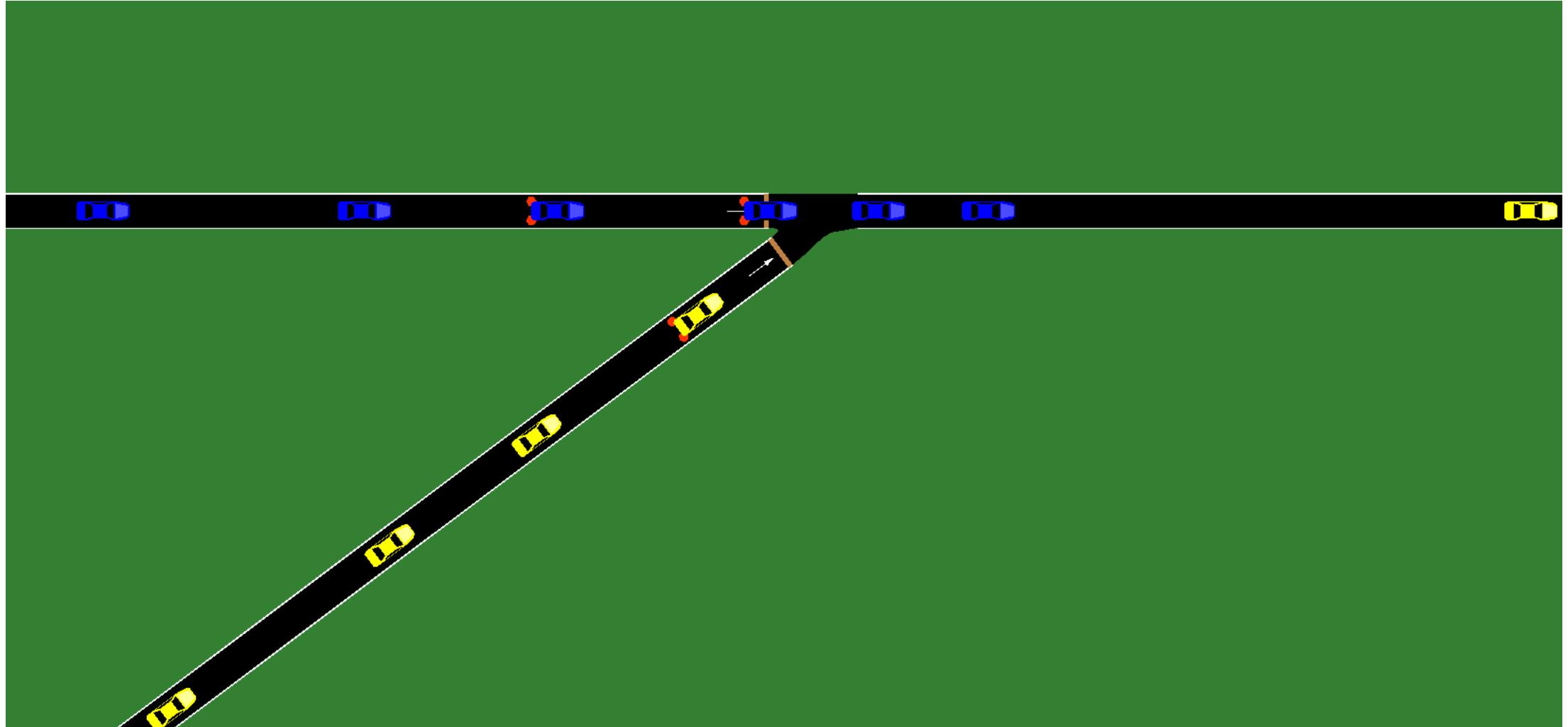
- 0 stars
- 1 watching
- 0 forks

Sections on the right side:

- Releases: No releases published. [Create a new release](#)
- Packages: No packages published. [Publish your first package](#)
- Languages: Python 100.0%
- Suggested workflows:
 - Publish Python Package: Publish a Python Package to PyPI on release. [Configure](#)
 - Django: Build and Test a Django Project. [Configure](#)
 - Pylint: Lint a Python application with pylint. [Configure](#)

仿真测试

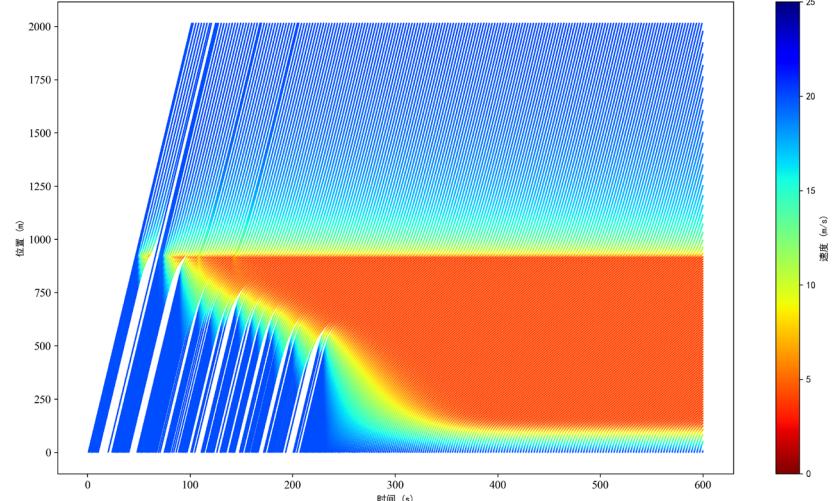
测试场景



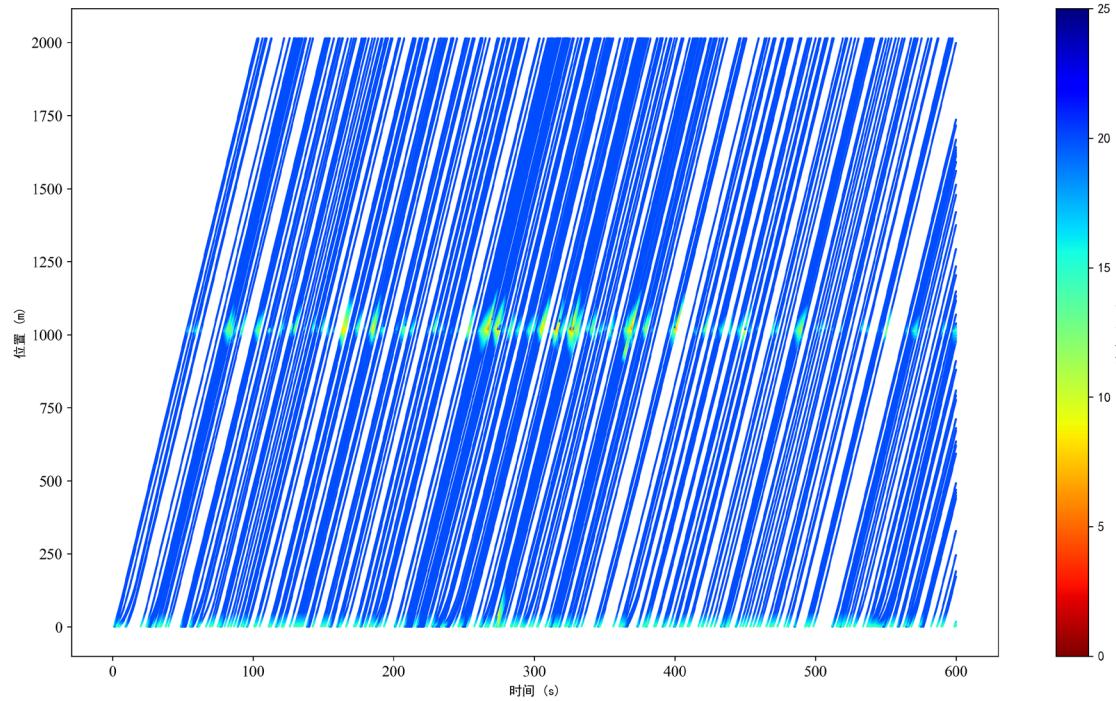
仿真测试

仿真效果

没有抢先整体协同



有抢先整体协同



在抢先整体协同道路交通系统中，进行高速仿真验证，解决车辆堵塞情况。

欢迎大家基于本研究提出的理念、成果进行后续研究、产品开发、商业应用。在进行成果发表及产品发布时，需注明以下参考文献。感谢支持！

1. Peng, Ting, et al. "Preemptive Holistic Collaborative System and Its Application in Road Transportation." arXiv preprint arXiv:2411.01918 (2024).
2. Tao, Li, et al. "Holistic view of the road transportation system based on real-time data sharing mechanism." arXiv preprint arXiv:2407.03187 (2024).
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4. Peng, Ting, et al. "Optimizing Highway Ramp Merge Safety and Efficiency via Spatio-Temporal Cooperative Control and Vehicle-Road Coordination." arXiv preprint arXiv:2408.08121 (2024).
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THANKS

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**Key Laboratory for Special Area Highway Engineering of Ministry of Education,
Chang'an University**

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