

# Sharing the Road

Understanding and Facilitating Mixed Traffic  
with Human-Driven and Autonomous Vehicles

Edited by Dengbo He,  
Xiaotong Sun, and Huan Yu



# Sharing the Road

With the advancements in sensor and computation technologies, connected autonomous vehicle (CAV) services are being tested and deployed on public roads, sharing the road with human-driven vehicles (HVs). This brings challenges to traffic safety, due to uncertainty in HVs behaviors. To address these challenges, *Sharing the Road* offers solutions to create a safer world where HVs and AVs mix freely on our roads.

Presented from a team of researchers from different domains offering varying perspectives, this book systematically summarizes the issues and trends of mixed traffic, from the micro (such as vehicle algorithm design) to the macro (including traffic flow optimization and policy) perspectives. Customized car-following models describing the behaviors of HVs when interacting with CAVs and control algorithms optimizing the traffic flow in terms of traffic safety and efficiency are discussed. The title also summarizes approaches to model HVs' behaviors and case studies of real-life examples are provided, leaving the reader with a detailed vision of the future of a mixed-traffic world.

This title will appeal to professionals at any career stage in the fields of human factor engineering, traffic engineering, urban design, and vehicle engineering.



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# Contents

Acknowledgements .....	vii
About the Editors .....	ix
List of Contributors .....	xi
<b>Chapter 1</b> Introduction .....	1
<i>Dengbo He, Huan Yu, and Xiaotong Sun</i>	
<b>Chapter 2</b> Empirical Research for Mixed Traffic Research .....	4
<i>Dengbo He, Xiaoyu Zhou, Yang Liu, and Jiahao Zhang</i>	
<b>Chapter 3</b> Tools for Micro Mixed Traffic Research .....	30
<i>Meixin Zhu</i>	
<b>Chapter 4</b> Micro–Macro Mixed Traffic Flow Modeling .....	42
<i>Jian Rong, Yi Wang, Chenjing Zhou, and Yue Chen</i>	
<b>Chapter 5</b> Safety of Mixed Traffic: Evidence from Empirical Studies .....	69
<i>Chunxi Huang, Tianhao Li, and Dengbo He</i>	
<b>Chapter 6</b> Environmental Impact of the Mixed Traffic and Countermeasures .....	87
<i>Ran Tu and Shan Xue</i>	
<b>Chapter 7</b> Case Study: Driver Performance Difference and Model Difference Evaluation on Different Car-Following Scenarios under Mixed Traffic Flow .....	99
<i>Yang Liu, Dengbo He, Xiaoyu Zhou, and Jiahao Zhang</i>	

<b>Chapter 8</b>	Case Study: Analysis of Mixed Traffic Flow.....	112
	<i>Jian Rong, Yi Wang, Chenjing Zhou, and Yue Chen</i>	
<b>Chapter 9</b>	Case Study: Mixed Traffic with Connected and Automated Vehicle Scenario in Southern California.....	132
	<i>Brian Yueshuai He, Qinhua Jiang, and Jiaqi Ma</i>	
<b>Index</b> .....		151

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# 1 Introduction

*Dengbo He, Huan Yu, and Xiaotong Sun*

## 1.1 WHAT IS MIXED TRAFFIC

Traditionally, the term “mixed traffic” refers to the heterogeneous traffic flow containing various vehicles—either motorized or non-motorized (Hidayati et al., 2014). In recent years, with the advancement of autonomous driving technologies and communication technologies, fully autonomous vehicles (AVs) or vehicles with some level of driving automation have been gradually entering the market. However, before they saturate the market, AVs and human-driven vehicles (HDVs) will inevitably have to share the road, leading to the traffic that consists of both AVs and HDVs. Being different from the traditional mixed traffic that consists of human road agents, the coexistence of both AVs and HDVs on the road can be more complex, given the subtle relationships between human users and automation (e.g., Madhavan & Wiegmann, 2007). In the current book, we will mainly focus on the traffic stream of AVs and HDVs, and frame such traffic stream as **mixed traffic** throughout the book.

## 1.2 THE RATIONALE OF THIS BOOK

Introducing AVs into the traffic flow brings several challenges and opportunities to traffic management and control. Although researchers in past decades have explored a wide range of traffic modeling and control topics, including the impact of new technologies (e.g., artificial intelligence, Hu et al., 2023), the introduction of AVs in the traffic flow can be more dramatic. Some key points are outlined here below:

- **AVs are still less than ideal and have different characteristics compared to HDVs.** Although driving automation technologies have been evolving dramatically and the crash rates of AVs have been decreasing in recent years (Zhou et al., 2024), in the foreseeable future, driving automation may perform differently compared to human drivers. Thus, the characteristics of AVs can impact traffic flow and traffic management. However, the AV-related data remains sparse at this stage. Hence, on the one hand, it is necessary to review the approaches taken by existing research that focused on mixed traffic and inform future research directions. On the other hand, it is also necessary to summarize the characteristics of the AVs in mixed traffic to inform future research.

- **The human drivers' adaptation to AVs needs to be considered.** It has been widely acknowledged that human operators may adapt their behaviors when interacting or cooperating with automation (Lee & Moray, 1994). Human road users may exhibit different strategies when interacting with AVs versus interacting with other HDVs. Hence, when modeling the mixed traffic, it is necessary to consider the behavioral changes of the HDVs. This book will review some of the approaches that have been found to be effective in modeling behavioral changes and discuss some of the behavioral changes that have already been recognized among human road users in mixed traffic.
- **Human road agents' attitudes and acceptance of AVs matter to mixed traffic.** Although AVs can be fully rational and designed to modulate traffic for specific purposes, the realization of these benefits depends on the design of AVs, the users' or potential users' acceptance/attitudes toward the AVs, and the correct modeling of the human-AV interactions. In this case, the research in mixed traffic also needs to take the road users' heterogeneity into consideration and model such heterogeneity when designing the policies or traffic control strategies. This is a relatively new perspective for traffic research, and we will also briefly discuss the approaches and findings in this direction.

### 1.3 CHAPTERS OVERVIEW

In **Chapter 2**, we will briefly review the empirical research approaches that have been used or can be used in mixed traffic research for data collection. The pros and cons of different research approaches will be discussed.

In **Chapter 3**, we will mainly discuss the tools for microscopic mixed traffic simulation, including data-driven and model-based approaches.

In **Chapter 4**, instead of focusing on micro driver behaviors, we provide more details regarding the traffic flow modeling in mixed traffic.

**Chapter 5** will further zoom out and compare macroscopic and microscopic traffic flow models in artificial and mixed traffic scenarios, highlighting their differences and applications. It also discusses simulation tools like VISSIM ([www.ptvgroup.com/en/products/ptv-vissim](http://www.ptvgroup.com/en/products/ptv-vissim)), AIMSUN ([www.aimsun.com](http://www.aimsun.com)), and SUMO (<https://eclipse.dev/sumo/>), which are used to model and evaluate these traffic conditions.

**Chapter 6** will discuss more about the characteristics of mixed traffic from the traffic safety perspective of view and **Chapter 7** will discuss the mixed traffic from the environmental impact perspective of view.

Finally, we provide three case studies, covering the topic of driver behavior modeling in mixed traffic (**Case Study 1**), modeling of mixed traffic flow (**Case Study 2**), and users' acceptance of mixed traffic as well as its impact on vehicle miles traveled and emissions (**Case Study 3**).

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