

Chapter 1-Introduction

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Abstract

This chapter introduces the some important concepts used throughout this book, rationale of the book, and the arrangement of the following chapters. This chapter will be a quick guideline to the readers of this book.

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 (AV) or vehicles with some levels of driving automation have been gradually entering the market. However, before the AVs saturate the market, the 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 co-existing of 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 this book, we will mainly focus on the traffic stream of AVs and HDVs, and we will frame such traffic stream as **mixed traffic** throughout the book.

1.2 The rationale of this book

Introducing AVs into the traffic flow brings challenges and opportunities to traffic management and control. Though 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.

- **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 still perform differently compared to human drivers. Thus, the characteristics of AVs can impact traffic flow and traffic management. However, the AV-related data is still 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 in order 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 to model the 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 the traffic for specific purposes, the realization of these benefits depends on the design of AVs, the users' or potential users' acceptance/attitudes towards 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 this 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 behaviours, we provide more details regarding the traffic flow modelling in mixed traffic.

Chapter 5 will further zoom out and compares macroscopic and microscopic traffic flow models in artificial and mixed traffic scenarios, highlighting their differences and applications. It also discusses simulation tools like VISSIM, AIMSUN, and SUMO, which are used to model and evaluate these traffic conditions.

Chapter 6 will discuss more about the characteristics of the 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 behaviour modelling in mixed traffic (**Case Study 1**), modelling of mixed traffic flow (**Case Study 2**) and users' acceptance of mixed traffic as well as its impact on vehicle miles travelled and emissions (**Case Study 3**).

Reference list

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