Transportation Engineering 17 (2024) 100264

Contents lists available at ScienceDirect

Transportation Engineering

journal homepage: www.sciencedirect.com/journal/transportation-engineering

Systematic review of overtaking maneuvers with autonomous vehicles

Josue Ortega [a], Martin Ortega [b], Karzan Ismael [c], Jairo Ortega [d], Sarbast Moslem [e,*]

[a] Department of Logistics and Transportation, Private Technical University of Loja, Loja, Ecuador
[b] Department of Electric, Electronic and Telecommunication, University of Cuenca, Ecuador
[c] Department of City Planning Engineering, Technical College of Engineering, Sulaimani Polytechnic University, Sulaimani 46001, Iraq
[d] Department of Transport Technology and Economics, Faculty of Transportation Engineering and Vehicle Engineering, Budapest University of Technology and Economics, Budapest, Hungary
[e] School of Architecture, Planning and Environmental Policy, University College Dublin, Dublin, Ireland

ARTICLE INFO

Keywords:
Autonomous vehicles
Fuzzy control
Intelligent transportation systems
Model predictive control
Overtaking maneuvers
PRISMA

ABSTRACT

The integration of intelligent transportation systems (ITS) in urban infrastructure has increased significantly, and one of the most notable examples is the development of autonomous vehicles (AVs). AVs have become a solution to various driving problems, such as performing complete overtaking maneuvers (OM). These maneuvers are considered one of the most difficult to carry out. Although there are many papers on OM maneuvers with AVs, not all of these studies focus on the performance of complete OM. Therefore, a comprehensive and scientific exploration of the analysis of complete OM with AVs is lacking. This study aims to address this gap through a systematic review following the PRISMA protocol as methodology, examining 51 articles published between 2008 and 2024 in the Science Direct, Scopus, and Web of Science (WOS) databases. The results showed that methodologies such as Model Predictive Control (MPC), Fuzzy Control (FC), and sigmoidal functions are used most to perform complete OM with AVs. MPC is the most relevant methodology due to its capability to be combined with other control systems and its predictive ability. FC and sigmoidal functions are also appropriate for dealing with inaccuracies and non-linear features associated with overtaking maneuvers. However, there are still complications related to computational complexity and sensor limitations. Future studies should consider and integrate the development of comprehensive systems that combine multiple real-time control methodologies and offer a robust combination of sensors. This review contributes to teaching studies that reveal promising opportunities for complete OM with AVs research and provide access to methodologies that could be optimized based on technological advances and emerging needs of the ITS sector. Addressing these knowledge gaps is essential to achieving safer and more efficient overtaking maneuvers by AVs.

Introduction

Nowadays, technology is becoming increasingly important in people's daily activities (Eisenmann et al., 2021). A clear example of this is autonomous transportation, in which the crew of a vehicle, whether a vehicle (Z. [1]), an aircraft (Deng et al., 2023 [2]), a vessel [3] or a truck [4], carries out several actions using artificial intelligence (AI) algorithms, sensors, Vehicle-to-Vehicle (V2V) or Vehicle-to-Infrastructure (V2I) communication (Hakak et al., 2023). This set of technologies is part of intelligent transportation systems (ITS), which have as a general function often improving in real-time the operation and safety of transportation [5].

V2V communication is a tool that enables the application of sending messages from one vehicle to other vehicles located at different distances. It means that if a vehicle close to the V2V system cannot establish a connection with the system, this vehicle becomes undetectable [6]. While the V2I tool refers to the exchange of information between vehicles and the infrastructure on the road, this can include traffic lights, traffic signals, and control centers. This connection enables different parts of intelligent transportation systems. Typically, road information is produced by one or more sources and sent to vehicles, or it is generated by vehicles and shared with the environment in which they operate [7].

Autonomous vehicles (AVs) are one of the most widely used technologies within the ITS field [8]. AVs are capable of fully autonomously performing all driving tasks on all types of roads, in all speed ranges, and in any weather conditions [9]. To achieve this, technologies such as

* Corresponding author.
E-mail address: sarbast.moslem@ucd.ie (S. Moslem).

https://doi.org/10.1016/j.treng.2024.100264
Received 22 January 2024; Received in revised form 22 July 2024; Accepted 27 July 2024
Available online 30 July 2024

global positioning system (GPS), radio detection and ranging (RADAR), and light detection and ranging (LIDAR) sensors, cameras, and sonar are employed [10]. The implementation of each of these sensors allows control of the velocity, acceleration, deflection, yaw angle, and global and local position of the AVs [11]. Moreover, these sensors enable the identification of roadway boundaries, road slopes, traffic signs, weather conditions, the state of obstacles (position, speed, acceleration, etc.), including other vehicles, and even the driver's state (vigilance, drowsiness, fatigue, boredom due to monotony, etc.) [12]. Furthermore, devices such as V2V and V2I communication can also be incorporated to ensure continuous data transmission and enable reactions to events that may occur during AVs' journeys (Z. [13]).

The combination of several of these sensors and devices generates diverse applications such as Advanced Driver Assistance Systems (ADAS) [14]. ADAS systems cover a series of systems that improve the safety of AVs, as well as other road users [15]. Some of these systems can also take control of AVs to prevent accidents or minimize their consequences [16]. These systems can act or react faster than a human would in events that may occur on the road ([17]; J. H. [18]; Gaio, A., & Cugurullo, 2023).

The adaptive potential of ADAS systems has led to the development of a variety of driver assistance systems such as (1) Adaptive Light Control (ALC), (2) Forward Collision Warning (FCW), (3) Automatic Emergency Brake (AEB), (4) Adaptive Cruise Control (ACC), (5) Lane Keeping System (LKS), and (6) Lane Change Assistant (LCA) [19–23].

ADAS systems can be implemented in several fields that involve the use of AVs, hence some scholars conduct systematic reviews on issues related to ADAS systems and [24–27]. Alawadhi et al. [28] performed a systematic review of the factors influencing the adoption of AVs, the results indicate that environments should be created for the imminent adoption of AVs. Duarte et al. [29] also conducted a review of research on the impact of AVs adoption in the city, showing that AVs offer great possibilities for redesigning cities and urban life. Martí et al. [30] surveyed a review of existing, novel and future sensor technologies for perception in automated driving and ADAS systems, giving rise to show how the application of sensors in AVs can solve tasks related to perception and detection.

Considering the different driving assistance systems, several studies have gone further and have developed methods to deal with the problems that AVs may face, including high-risk maneuvers such as complete overtaking maneuvers (OM). The OM is considered one of the most challenging and complex maneuvers that a vehicle can perform [31]. Anindyaguna et al. [32] mention that the OM is responsible for about 4 % and 10 % of collisions in accidents. Despite the high risk involved in performing complete OM, few studies have focused on the development of the maneuver. A clear example of this is the study by X. Zhang et al. [33] where a systematic literature review was performed in search of critical scenario identification (CSI) for automated driving systems, resulting in the possible driving scenarios that ADAS and AVs systems may face. Another example is the research performed by Nalic et al. [34] which presented a study with different scenario generation and evaluation methods for automated driving systems. Likewise, Prochowski & Szwajkowski [35] developed a study of research scenarios AVs. In all these studies the complete OM scenario is not relevant.

Despite the advances, a significant gap remains in understanding the challenges and complexities associated with executing high-risk maneuvers, such as complete overtaking maneuvers (OM) with autonomous vehicles. Therefore, the present study addresses the following research contributions:

1. Literature Review. In the context of autonomous vehicles, a systematic review of existing approaches for performing overtaking maneuvers is presented. This review addresses the gap identified in the existing literature on the subject.
2. Efficacy Evaluations. Method effectiveness evaluations are carried out to analyze the different approaches in the application of the maneuver, in order to provide a comprehensive view of its practical implementation and performance.
3. Innovative Methodology. Demonstrate innovative methods and application examples for executing safe and efficient maneuvers, utilizing Advanced Driver Assistance Systems (ADAS) and sensor technology.

Overall, the main objective of this study is to investigate the different approaches employed in the creation of a complete maneuver. It seeks to contribute to the existing body of knowledge with the purpose of laying the foundation for future studies and advances in this area. This contribution is expected not only to improve the safety and efficiency of AVs and ITS but also to drive progress in this field. Consequently, the purpose of the present systematic review is to investigate the various approaches used in the development of complete OM in the context of AVs and to contribute to filling this knowledge gap, thereby providing a solid foundation for future studies and developments in the field.

Based on the analysis of the existing literature, several lines of research for future studies in AVs are identified. First of all, one area of research could focus on developing and improving ADAS systems for performing complete OM and thus improving the safety of AVs and other road users. Second, research should be conducted on human interaction during transition phases and maneuvering scenarios with mixed traffic in which AVs and human-driven vehicles coexist. Finally, it is crucial to examine in depth the ethical implications of decisions made by AVs, especially in situations where human lives are at risk. Therefore, future studies can focus on developing innovative approaches to address these future studies and evaluate the effectiveness of such solutions in different contexts. Overall, these research areas can help advance the field of AVs and ITS and contribute to developing safer and more efficient transportation systems.

This study is organized as follows: Section II details the methodology employed, including the systematic review approach and study selection criteria. Section III presents the results obtained from the research, including key findings and trends identified. Section IV provides an in-depth discussion of the results, analyzing their implications and making connections with previous research. Finally, Section V presents the conclusions of the study, highlighting the contributions made to the field and suggesting possible directions for future studies.

Materials and methods

For this study, several papers were selected and reviewed using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol. This protocol has been adopted by many scientific journals and is mainly used to enhance the quality and transparency of information presented in systematic reviews and meta-analyses [36]. PRISMA has several advantages over other reviews. For instance, it employs a total of 27 elements that detail (1) the study selection process, (2) assessment of the risk of bias, (3) data extraction, and (4) statistical analyses performed [37]. Another important advantage of the PRISMA protocol is its update of advancements in the methods for identification, selection, appraisal, and synthesis of research studies in papers [38].

Nielsen et al. [39] reviewed 11 papers published in a search base of 1155 using the PRISMA protocol. Through this protocol, the authors were able to screen a list of references to determine whether Patient-Specific Rehearsal (PsR) for endovascular procedures in virtual reality improved performance in real-life scenarios. Regona et al. [40] employed a review of 72 papers out of 886 to identify the challenges and opportunities for the adoption of Artificial Intelligence (AI) in the construction sector. Kaye et al. [41] carried out a PRISMA systematic review in which 35 papers were selected to identify user acceptance of automated vehicles, from conditional (Level 3) to full (Level 5). The study by Bouraima et al. [42] included 49 articles published between January 2000 and June 2022 and two recent World Bank reports on rail transport in Africa to identify research and policy gaps for African rail transport planners and their development partners to consider. Also, Demir et al. [43]. reviewed 1374 articles between January 2020 and March 2023 from Scopus to evaluate the robustness of the application of Multi-Criteria Decision Making (MCDM).

In general, the PRISMA protocol facilitates researchers to perform research across various databases, such as Science Direct, Scopus, or Web of Science (WOS). Furthermore, it enables the generation of a synthesis of the state of knowledge in a particular area, considering aspects such as the status and language of the publication, study design, population of interest, duration, publication year, and sources of research [44].

A. Data collection

The systematic search was realized in July 2024 on public databases such as ScienceDirect, Scopus, and WOS. The combination of terms that yielded the best results in these databases was as follows:

(1) "autonomous vehicle" AND "maneuver" AND "overtaking".
(2) (ALL=(autonomous vehicles OR autonomous vehicle) AND ALL=(maneuvers OR maneuver) AND ALL=(overtaking)).

The terminology in label 1) was used in two public databases: ScienceDirect and Scopus, while the terminology in label 2) was used in the WOS database. Specifically, 471 papers were obtained from ScienceDirect, 476 papers from Scopus, and 98 papers from WOS, resulting in a database of 1045 papers. Prior to the paper selection process, inclusion and exclusion criteria were defined.

B. Inclusion criteria

All studies related to AVs that carried out complete OM were selected. Fig. 1 graphically illustrates the three phases involved in the overtaking process of AVs. The first phase begins when the AVs first moves from its original lane (1) to a secondary lane (2), which may have the same or a different direction of traffic. In the second phase, the AVs moves in a straight line until overtaking the slow vehicle (SV) in the secondary lane (2) to complete the overtaking. Finally, in the third phase, the AVs returns to the original lane (1) after changing lanes from the secondary lane (2). The OM ends when the AVs returns completely to its original lane (1) and resumes driving straight ahead.

C. Exclusion criteria

Doctoral and master's dissertations, book chapters, editorial notes, press articles, industry reports, non-English language papers, and simulations that did not perform a simulation or complete OM were excluded.

D. Study selection

According to these criteria, 1045 papers were considered eligible. Seventy-seven papers were eliminated due to duplication. The titles were read, and based on this reading, 349 papers were excluded, mainly due to containing elements that met the exclusion criteria. After eliminating 568 papers based on the review of abstracts, 51 papers that met the inclusion criteria were selected and included in the systematic review.

For a better visualization of the selection systems for the systematic review, the study selection scheme is summarized in Fig. 2. Furthermore, the information compiled from the selected documents is available in the annex as a result of the review.

Results

The analysis presented below is organized in a logical and coherent sequence, designed to optimize the understanding and interpretation of the results, thus facilitating the integration of the findings into the theoretical and practical framework of the topic of study. This analysis is composed of three main parts: A) Distribution of papers by journal and conference proceeding, which presents a breakdown of publications according to academic sources; B) Distribution of papers by method, which examines the methodologies employed in the studies reviewed; and C) Mapping process, which illustrates the flow of information and the relationships between the different stages of research and development in the field of study.

A. Distribution of papers by journal and conference proceeding

The 51 papers included in the systematic review were distributed through journals and conference proceedings. Table 1 shows the first distribution, which consists of 41 journals, 100 % of which are indexed in Scopus. Moreover, 18 journals, in addition to being indexed in Scopus, are also indexed in WOS. The second distribution, which is composed of the remaining 10 papers (see Table 2), also has 100 % indexing in Scopus. However, no indexing is recorded in WOS.

The variety of specialized publications is evidence of the interdisciplinary nature of research on overtaking maneuvers with AVs, addressing aspects such as safety, control systems, sensor technologies, and vehicle dynamics. The articles explore issues that demonstrate the multifaceted and multidimensional nature of topics related to virtual assistants (VAs). Furthermore, conferences play a crucial role in research

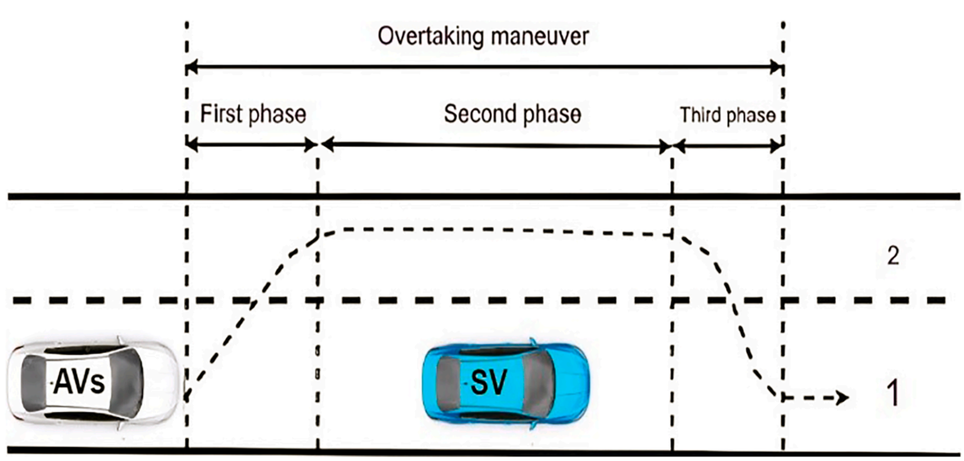

Fig. 1. Diagram of complete OM performed by an Autonomous Vehicle (AVs) when approaching a Slower Vehicle (SV). The AVs moves to the secondary lane (2) to overtake the SV and then returns to the original lane (1).

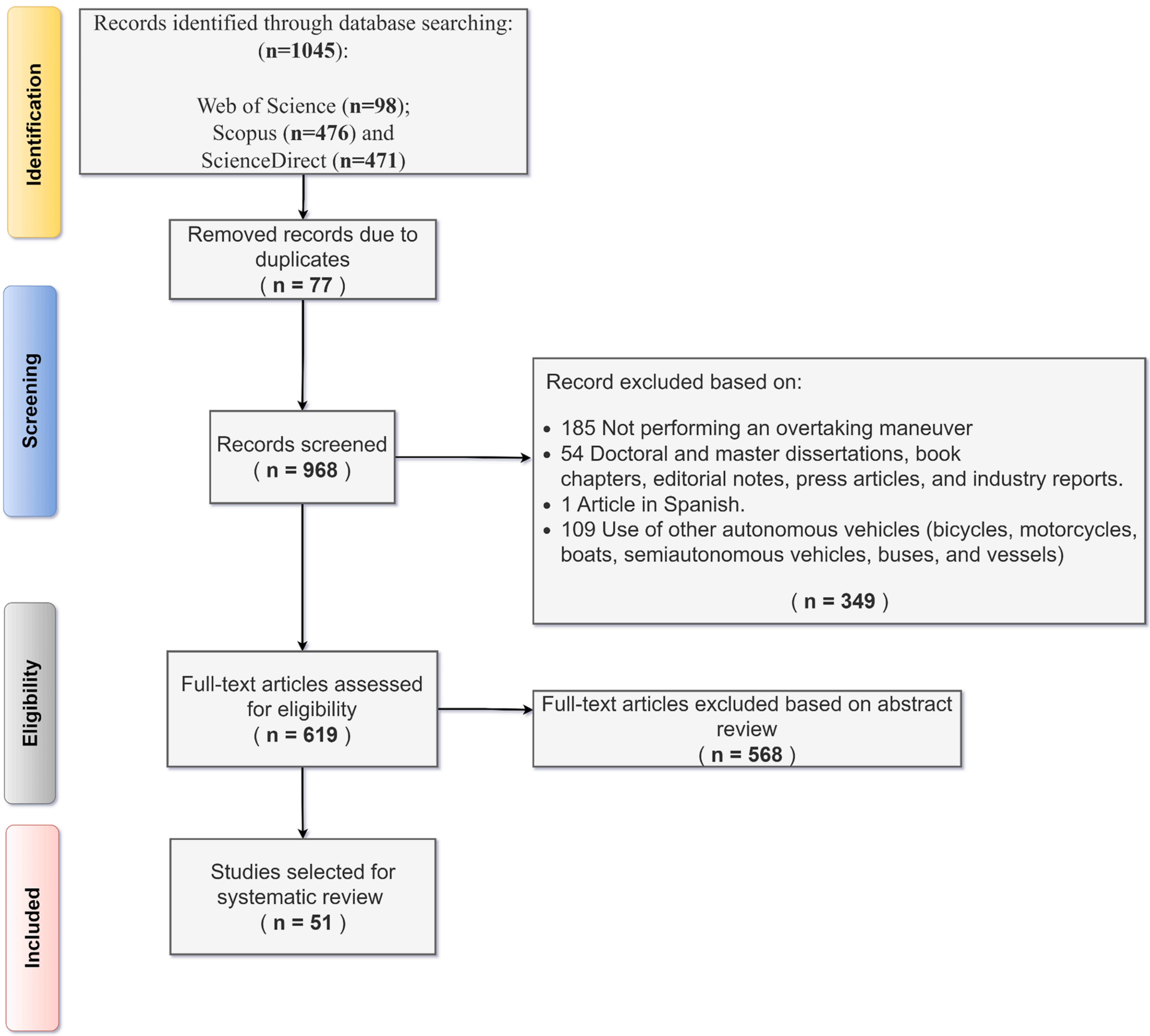

Fig. 2. Flow chart of the elements of the systematic review (PRISMA).

as they serve to distribute the most recent scientific breakthroughs and promote dialogue. Typically, these places provide a forum for scholars to present and promote their ideas in new fields.

B. *Distribution of papers by method*

Table 3 presents the different methods used to perform complete OM with AVs. The results indicate that the sigmoidal function is the most used method, with a contribution of 6 %, while ACC and Technology, Independent Sensors (TIS), Rendezvous Guidance (RG), Fuzzy Control (FC), and MPC are the second most used approaches by the researchers, with a percentage close to 4 %. The other techniques are used only once.

The reason that several authors apply the sigmoidal function more frequently than other methods could reside in the flexibility, smoothness, ease of parameterization, and computational efficiency for modelling the trajectory of a vehicle during complete OM in an autonomous driving scenario.

Several authors also prefer fuzzy control (FC) because it adapts to real-time variables, enabling AVs to make safe and efficient decisions in changing traffic situations. Combining FC with other methodologies, such as stereo vision system (SVS) and embedded digital signal processors (EDSP), highlights its versatility and effectiveness.

Model-based predictive control (MPC) is notable for its adaptability and capacity to incorporate diverse systems, including fuzzy logic, geometric interpolation, and deep learning algorithms. This enhances its effectiveness in varied driving scenarios. The capability to forecast future vehicle conditions and optimize control actions in real-time makes it a prominent method for studying entire overtaking maneuvers.

C. *Mapping the process*

The systematic review included all papers published up to the date of selection. An increase in the number of papers related to complete OM is evident, especially in 2023 and 2020, with nine and eight papers, respectively, followed by 2018 with seven papers. Likewise, it is seen that in 2021, there were seven papers. Comparing these numbers with previous years (2008, 2009, 2011, 2012, etc.), a significant increase in the study and publication of topics related to autonomous vehicles and the complete OM is evident (see Fig. 3).

The evolution of research in the field has been significant, starting

Table 1
Distribution of papers by journal.

Name of the journal	Database	Number of publications	Percentage
Ain Shams Engineering Journal	Scopus and WOS	1	2,44 %
Ceur Workshop Proceedings	Scopus	1	2,44 %
Engineering Science and Technology-An International Journal	Scopus and WOS	1	2,44 %
Expert Systems with Applications	Scopus and WOS	1	2,44 %
Communications Letters	Scopus and WOS	1	2,44 %
Systems Journal	Scopus and WOS	1	2,44 %
Transactions on Cybernetics	Scopus and WOS	1	2,44 %
IFAC Proceedings Volumes	Scopus	1	2,44 %
Simulation Modelling Practice and Theory	Scopus and WOS	1	2,44 %
Strojnicky Casopis	Scopus	1	2,44 %
Transportation Engineering	Scopus	1	2,44 %
International Journal of Automotive Technology	Scopus	1	2,44 %
Energy Reports	Scopus	1	2,44 %
Transportation research record	Scopus and WOS	1	2,44 %
Automotive Innovation	Scopus	1	2,44 %
Energies	Scopus	1	2,44 %
IEEE ACCESS	Scopus and WOS	1	2,44 %
International Journal of Systems Science	Scopus and WOS	1	2,44 %
Journal of Advanced Transportation	Scopus and WOS	1	2,44 %
Journal of Intelligent \& Robotic Systems	Scopus and WOS	1	2,44 %
Journal of Intelligent Transportation Systems	Scopus and WOS	1	2,44 %
PLOS ONE	Scopus and WOS	1	2,44 %
Proceedings of The Institution of Mechanical Engineers Part d-Journal of Automobile Engineering	Scopus and WOS	2	4,88 %
Robotics and Autonomous Systems	Scopus and WOS	3	7,32 %
Transactions on Intelligent Transportation Systems	Scopus and WOS	3	7,32 %
Electronics	Scopus and WOS	3	7,32 %
IFAC-PapersOnLine	Scopus	8	19,51 %
Total		41	100%
Total indexed in Scopus		27	
Total indexed in WOS		18	

Table 2
Distribution of papers by Conference proceeding.

Name of conference proceeding	Database	Number of publications	Percentage
International Conference on Mechatronics (ICM)	Scopus	1	10,00 %
International Conference on Vehicular Electronics and Safety (ICVES)	Scopus	1	10,00 %
Electric Vehicles International Conference (EV)	Scopus	1	10,00 %
International Conference on Communications Workshops (ICC)	Scopus	1	10,00 %
Vehicular Technology Conference	Scopus	1	10,00 %
International Conference on Automation and Logistics (ICAL)	Scopus	1	10,00 %
International Symposium on Systems Engineering (ISSE)	Scopus	1	10,00 %
Transportation Research Procedia	Scopus	1	10,00 %
Conference on Intelligent Transportation Systems (ITSC)	Scopus	2	20,00 %
Totala		10	100 %
Total indexed in Scopus		9	
Total indexed in WOS		0	

from initial theoretical frameworks to practical applications and testing in real environments. Initially, studies on complete OM focused on theoretical and simulation studies in order to understand the maneuver. These early studies gave the background for developing advanced models and their application in real situations. Overtaking maneuvers have been optimized by integrating and comparing various methods, which has contributed to making them safer and more efficient.

Discussion

This section presents a detailed analysis of various methods used to execute complete overtaking maneuver (OM) with autonomous vehicles (AVs) based on an extensive literature review. The study examines a wide range of strategies used in this area. Furthermore, an evaluation of the advantages and disadvantages of these methods is included to provide researchers with a guide for future studies or research.

- **Passing Sight Distance Using Vehicle Dynamic Response (PSD):** The PSD methodology refers to the minimal separation required for a driver to pass another vehicle safely on a two-lane road without affecting the flow of traffic from the other direction. This methodology considers variables such as the speed of the vehicle, its ability to accelerate, the incline of the road, and the weather affecting visibility. The study conducted by Raj et al. [45] applies the PSD methodology to carry out complete OM.
- **Field measurements:** One approach to carrying out maneuvers involves utilizing real-time measurements collected by GNSS (Global Navigation Satellite System) receivers. Mavromatis et al. [46] employ this technique to accurately record the motions and locations of vehicles during overtaking maneuvers, including factors such as velocity, acceleration, and road curvature.
- **Sigmoid Function Approach:** An outstanding method in complete OM is the use of sigmoid functions, as demonstrated in the studies of X. Huang et al. [47], Ben-Messaoud et. (2018) and Vigne et al. [48]. With this method, the smoothness of the maneuver and the safety distance between vehicles is precisely controlled. The nonlinearity becomes advantageous for modelling complex systems with input-output relationships.
- **Adaptive Cruise Control (ACC) with Technology Independent Sensors (TIS):** The methodology used in the studies carried out by Ortega et al. [49,50] and Magdolen et al. [51] shows how the integrated use of ACC and TIS allows AVs to control speed, acceleration, and braking during overtaking. Moreover, if camera-based sensors are added to this integration, the possibilities of performing a maneuver in general improve.
- **Rendezvous Guidance (RG):** RG proves to be a solid choice for complete OM, as it offers precise control of the trajectory and speed of the AVs, as demonstrated in the studies of [52,53].
- **Fuzzy Control (FC):** FC is known for its adaptability to real-time variables, allowing AVs to make safe and efficient decisions. The ability of FC to control multiple aspects, such as vehicle speed, position relative to the vehicle in front, distance between vehicles, and acceleration, are remarkable [54,55]. Several studies integrate FC with other techniques, such as the stereo vision system (SVS) and the integrated digital signal processor (EDSP), which highlights the versatility and effectiveness of FC [56,57].
- **Model-Based Predictive Control (MPC):** MPC presents several real-time combinations in several scenarios. The flexibility of this method is evident in its integration with multiple systems including Defeasible Deontic Logic (DDL), Fuzzy-inference-based reinforcement

Table 3
Distribution of papers by method.

Name of the method	Number of publications	Percentage
Sigmoid function	3	6 %
ACC and TIS	2	4 %
RG	2	4 %
FC	2	4 %
MPC	2	4 %
TIS and Camera	1	2 %
Hierarchical framework (HF) with Finite-State Machine (FSM)	1	2 %
FSM and MPC	1	2 %
Anticipatory kinodynamic motion planner	1	2 %
Fuzzy-inference-based reinforcement learning (FIRL)	1	2 %
Harmonic potential (HP) with MPC and fuzzy adaptive controller (FAC)	1	2 %
Mixed Observability Markov Decision Process (MOMDP)	1	2 %
Guidance navigation control	1	2 %
Spline-based interpolation strategy	1	2 %
MPC and Tire-Road Friction Coefficient (TRFC)	1	2 %
Clustering methods and probability density functions	1	2 %
Stochastic control	1	2 %
MPC with Proportional-Derivative (PD) and Fuzzy Inference System (FIS)	1	2 %
Supervised learning approach	1	2 %
Hierarchical (H-MPC)	1	2 %
Behavior and path planning algorithm (BPPA)	1	2 %
FIS and Q-learning framework	1	2 %
Adaptive nonlinear adaptive controller (ANAC)	1	2 %
Modular control framework (MCF) and MPC	1	2 %
Swarm intelligence algorithm	1	2 %
Embedded digital signal processor (EDSP) and FC	1	2 %
Overtaking Procedure for Collision Avoidance Systems (OP-CAS)	1	2 %
Clothoid Tentacles	1	2 %
V2V and POSition-ACCuracy (POSACC)	1	2 %
Stereo vision system (SVS) and FC	1	2 %
Quadratic Programming (QP) with MPC	1	2 %
Time to lane crossing (TLC) and MPC	1	2 %
Defeasible Deontic Logic (DDL)	1	2 %
Geometric Hermite Interpolation (GHI)	1	2 %
Measurement-based decision framework (M-DF) with System Modeling Language (SysML)	1	2 %
Deep deterministic policy gradient (DDPG)	1	2 %
Legal, logic and Engineering Analyses (LLEA)	1	2 %
Control Lyapunov function (CLF) and Control Barrier Function (CBF)	1	2 %
System-level framework	1	2 %
Dual-variable trajectory planning framework	1	2 %
Convex Optimization	1	2 %
Field measurements	1	2 %
Coordinated control design with MPC	1	2 %
Passing Sight Distance Using Vehicle Dynamic Response	1	2 %
Control barrier functions and MPC	1	2 %
Total	51	100 %

learning (FIRL), Geometric Hermite Interpolation (GHI), Measurement-based decision framework (M-DF) with System Modeling Language (SysML), Deep deterministic policy gradient (DDPG), Legal, logic and Engineering Analyses (LLEA), Overtaking Procedure for Collision Avoidance Systems (OP-CAS), Clothoid Tentacles, Vehicle-to-Vehicle (V2V) and POSition-ACCuracy (POS-ACC), swarm intelligence algorithm, behavioral algorithm and path planning, Fuzzy Inference System (FIS) and Q-learning framework, nonlinear adaptive controller, supervised learning approach, clustering methods and probability density functions, stochastic control, Mixed Observability Markov Decision Process (MOMDP), guidance navigation control, spline-based interpolation strategy, Hierarchical framework (HF) with Finite-State Machine (FSM) and anticipatory kinodynamic motion planner, CLF and CBF, Coordinated control design with MPC, Control barrier functions and MPC, Convex Optimization, Dual-variable trajectory planning framework, ystem-level framework [58–82], (G. Li, Zhang, et al., 2023), [83,84]. The extensive adoption of MPC in combination with other systems indicates its dominance in complete OM research.

Once the different methods used to carry out complete OM with AVs have been analyzed, a deeper examination of the strengths and weaknesses of each method can be made, which is essential for researchers and policy makers concerned.

Advantages of current technologies

- **Improved safety:** The application of OM methods, such as the sigmoid function, Adaptive Cruise Control (ACC) with Technology Independent Sensors (TIS), and Rendezvous Guidance (RG), have demonstrated notable success in improving safety during overtaking maneuvers. The ability to adjust smoothness, control the trajectory, and keep safe distances contribute to reducing the risk of collision.
- **Real-time adaptability:** Fuzzy control (FC), Field measurements, and Model-Based Predictive Control (MPC) offers real-time adaptability, allowing AVs to respond to changing variables and dynamic traffic conditions.
- **Versatility:** The flexibility offered by MPC control and PSD, when integrated with other control systems, offers a wide range of solutions for different scenarios and requirements.
- **Robustness:** The Rendezvous Guidance (RG) system provides robust control over AVs by providing accurate and reliable control over trajectory and speed. This makes it a reliable choice for OM.

Cons of current technologies

- Complexity and overhead: Advanced methods such as MPC can generate computational overhead, which can affect real-time performance. Therefore, it is important for researchers to seek and find a balance between sophistication and computational efficiency.
- Sensors: The use of sensors in technologies such as camera-based systems may have limitations in rough environments or adverse weather conditions. Guaranteeing robustness in all environments is essential.
- Privacy and security: As AVs need data for decision-making, privacy and security issues become prominent, resulting in the data that this technology acquires being important. This requires robust measures to protect users' sensitive data or information.
- Human-Autonomous Vehicle Interaction: The lack of regulations or laws for the implementation of AVs could obstruct the adoption and integration of AVs into people's mobility. Therefore, collaboration between industry and policy actors is needed to establish clear regulations.

In general, understanding the strengths and weaknesses of the methods and technologies that interact to perform complete OM with AVs is important for making decisions and driving research. Researchers should also consider the advantages and cons of this technology (AVs) when testing it in everyday situations such as complete OM. Thus, the development of safe and efficient autonomous overtaking maneuvering techniques can be encouraged.

The systematic review revealed that the sigmoid function, Passing Sight Distance Using Vehicle Dynamic Response (PSD), Field measurements Adaptive Cruise Control (ACC) with Technology Independent Sensors (TIS), and Rendezvous Guidance (RG) provide essential functions. For example, the sigmoid function PSD, Field measurements, and RG, due to their computational efficiency and smooth trajectory generation, improve maneuvering safety. ACC with TIS also provides the ability to improve maneuvering safety by controlling speed and braking.

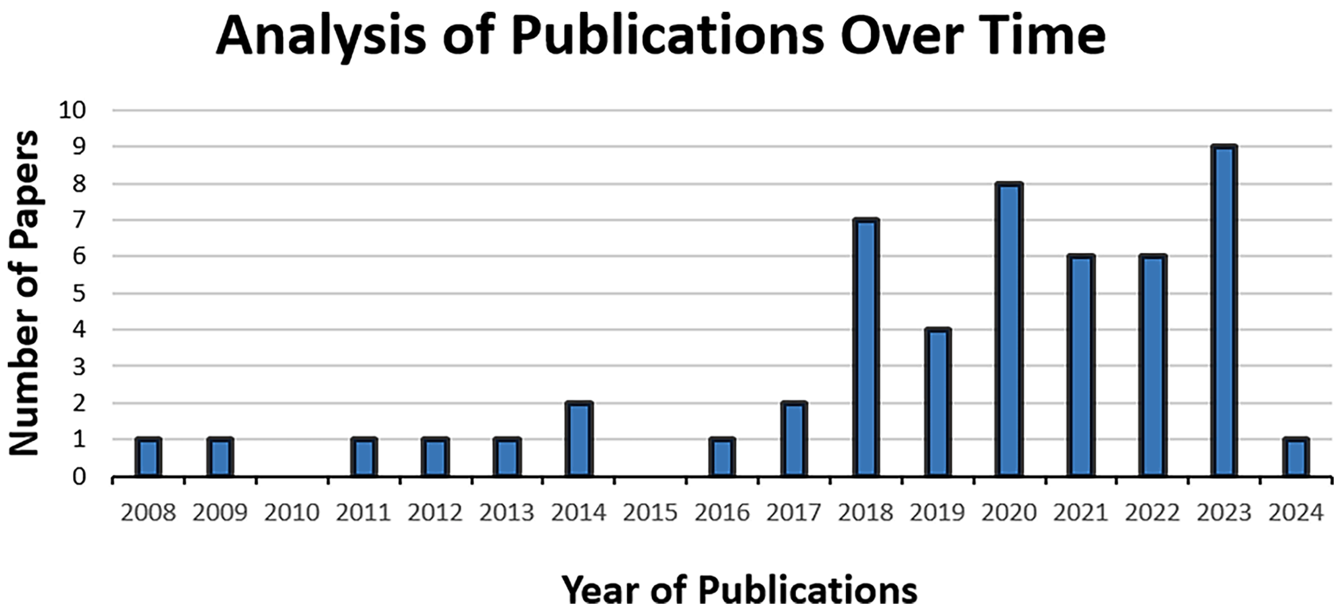

Fig. 3. Analysis of articles by year of publication (2008–2024).

However, MPC is the most important strategy due to its complete real-time optimization and adaptability.

Future studies should explore the integration into the design of effective human-AVs interaction mechanisms, with the development of intuitive environments and communication protocols that ensure safe driving between autonomous and manual driving modes. It is also recommended that rigorous testing and validation procedures be developed to assess the safety of methods for performing complete OM with AVs. Real-world testing, simulation, and accreditation processes are essential components.

The limitations during the development of this study were the selection of papers from the PRISMA checklist. Furthermore, the screening and review of papers based on search terms could affect the completeness of the review article. Further work to address these limitations could be an interesting extension of this work.

Conclusion

In the broad topic of autonomous vehicles (AVs), the study of high-risk maneuvers, such as the overtaking maneuver (OM), has been the subject of great interest among researchers. This study focused on an exhaustive study of the methodologies and techniques used to perform complete OM with AVs. In order to understand what is involved in the performance of this maneuver, this study, through a systematic review, made a meticulous analysis that aims to throw light on the different approaches, methodologies, and systems that support the performance of this maneuver with AVs.

The systematic study allowed the elaboration of a PRISMA protocol designed for the object of study: investigate the methods applied in different studies to achieve complete OM with AVs. The results revealed a remarkable trend in OM research over the years between 2008 and 2024. This progressive increase shows the interest of researchers and the relevance of OM within the field of autonomous driving. Likewise, the variety of methods to elaborate complete OM is evident, being the sigmoid function method and the combinations of fuzzy control (FC) and model-based predictive control (MPC) as the most used options by researchers. The choice of these methods may be due to the flexibility of adaptability, accuracy, and computational efficiency offered to the AVs during OM.

In conclusion, this study contributes to the understanding of the several methods and systems used in the execution of complete OM with AVs. Also, future studies or research may benefit significantly from this work and eventually lay the groundwork for future studies to improve the identification, search, and analysis of the methods applied in the maneuver.

CRediT authorship contribution statement

Josue Ortega: Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Martin Ortega:** Writing – original draft, Methodology, Investigation, Formal analysis. **Karzan Ismael:** Investigation, Visualization, Writing – review & editing. **Jairo Ortega:** Writing – review & editing, Visualization, Methodology, Conceptualization. **Sarbast Moslem:** Writing – original draft, Visualization, Validation, Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

Acknowledgments

Thanks to the Universidad Técnica Particular de Loja from the Republic of Ecuador for their collaboration and support.

Appendix A

Application of methods for carrying out complete overtaking maneuver.

No	Author(s) & year	Method	Methodology	Gap & research problem	Result & Outcome
1	[85]	Sigmoid function	Combining parameterized sigmoid functions and a rolling horizon for smooth trajectory generation in a low execution time	The creation of a feasible continuous curvature path to avoid collisions with a vehicle, a pedestrian or any obstacle	Perform static and dynamic obstacle avoidance maneuvers through an algorithm.
2	[48]	Sigmoid function	Optimization of a sigmoid function in order to generate a trajectory of an OM that in turn is based on a driving style.	Traffic accidents, traffic jams, by choosing a driving style (relaxed/ sporty).	Generation of a trajectory for an OM based on a driving style.
3	[47]	Sigmoid function	Apply geometric curves and sigmoidal functions that are configured according to the current relative distance and speed with respect to the preceding vehicle for lane keeping and lane changing motions.	The capabilities of using sigmoid functions in vehicle overtaking scenarios	Effectively manage the OM by a control framework that performs decisions by itself
4	(Ortega et al., 2023)	ACC and TIS	Using PreScan software, a scenario is created in which an AVs is equipped with TIS sensors and an ACC system to carry out an OM on another vehicle ahead.	Difficulty in overtaking a vehicle ahead in the company of other vehicles traveling in other lanes.	Reduce the risk of collision during the OM.
5	[50]	ACC and TIS	Through the use of a simulation software called PreScan, which includes ACC systems and TIS sensors, an OM of an AVs overtaking another vehicle ahead is carried out.	Increase the understanding of the OM through the use of simulation software and ACC systems with TIS sensors.	Carrying out an OM of an AVs in an urban environment where conventional vehicles are also circulating.
6	[53]	RG	The vehicle performing the OM, through the sensory information collected from the vehicle ahead, adapts its position and velocity in real time.	Produce on-line trajectories to generate or abort autonomous overtaking in emergency situations	Adjust in real time driving parameters of the vehicle which performs the OM to another vehicle that shows variations in the driving parameters.
7	[52]	RG	A modified RG algorithm was used to perform path planning and obstacle avoidance scenarios for autonomous overtaking.	Carrying out intelligent and safe OM	The time required to perform the OM is reduced by 10 % using the RG algorithm.
8	[54]	Fuzzy control	With the help of systems such as fuzzy controllers, human behaviors and reactions are imitated to execute OM.	Lack of coverage of actions taken in OM	The AVs is able to overtake another vehicle traveling in the same lane of the road.
9	(Perez et al., 2011)	Fuzzy control	Development a decision-making system based on fuzzy logic which longitudinally controls an AVs when overtaking another vehicle.	There is a need to develop a decision system for OM with AVs, without modifying the current road infrastructure.	Controlling AVs in high-risk scenarios through longitudinal architecture
10	[51]	TIS and Camera	With the PreScan simulation software, a scenario is developed that implements TIS sensors and camera to execute an OM with AVs.	Design a safe OM model without collisions between vehicles.	The AVs interacts with its urban environment and adjusts its pre-selected trajectory to avoid an obstacle
11	[64]	LLEA	The model generates variable calculations such as time/distance to collision and time/distance to OM, the model shows variable speeds and accelerations during the overtaking. Finally, the model evaluates factors such as the safe distance in the opposite direction in order to avoid-head-on-collision or safe-lateral distance.	Overtaking models developed only for designed operational domain and simplified overtaking scenarios on highways with median separated traffic.	The model enables the Ego vehicle to deal with complex overtaking situations in two lanes of urban and rural roads.
12	[67]	DDPG	The method uses low-cost sensors such as ultra-wideband antenna arrays and inertial measurement units. These sensors allow measurements that are easy to obtain, such as distance, angle and speed information.	Expensive autonomous driving systems require LIDAR or visual camera sensors to get distance, angle and speed measurements.	The DDPG model outperforms the fuzzy control and the deep Q-network (DQN) algorithms in decision making.
13	[59]	SysML	A model-based system engineering approach is applied to develop virtual models and get vehicle overtaking designs.	Implement measurement-based decision-making strategies for AVs that consider safety and collaboration between drivers.	The overtaking model is able to deal with complexes, develop virtual prototypes for analysis and generate design requirements.
14	[70]	GHI	The GHI algorithm calculates a trajectory from data that are predefined points including tangent angles and curvature values and thus determine safe speeds for autonomous driving.	Build continuous trajectories with AVs, in order to offer comfort and relaxation to the passengers.	The maximum safe driving speed during an OM is estimated.
15	[60]	DDL	Validate the AVs driving behavior by DDL	Validating the AVs behavior	The validation system improves AVs safety in the current transportation system.

(continued on next page)

(*continued*)

No	Author(s) & year	Method	Methodology	Gap & research problem	Result & Outcome
16	(Dang et al., 2022)	MPC	Based on a planner which uses a trajectory generation algorithm and MPC, a maneuver is selected among all possible maneuvers.	Select the best maneuver in autonomous driving	The ego vehicle can perform the OM at the desired speed and avoid collisions with the algorithm.
17	(Lin et al., 2021)	TLC and MPC	A vision-based detection system is used to estimate the TLC, which decides whether to overtake or stay within the lane. The MPC is then utilized to determine the optimal time for executing the OM.	Increase driving safety during OM and reduce unnecessary acceleration and rough steering.	TLC and MPC-based control systems for OM guarantee driving safety
18	(Coskun et al., 2021)	QP with MPC	The traffic condition is evaluated and a safe trajectory is executed in an OM with approaching traffic. For this purpose, a reachability analysis based on dynamic predictive models of the surrounding vehicles is used in the design.	Carry out autonomous driving maneuvers to overtake other vehicles while respecting regulatory and environmental constraints, considering the movements of vehicles close by that may be in motion.	The planning demonstrates an accurate real-time application of safe maneuvers in the face of unexpected traffic situations.
19	[57]	SVS and FC	A fuzzy logic-based controller emulates the way humans overtake. Meanwhile, a stereoscopic vision system is used to detect vehicles.	Develop an automated solution for OM in AVs.	The system provides a reliable solution for the automation of the OM. Its capabilities and features allow for efficient and safe execution of the maneuver in AVs.
20	[61]	V2V and POSACC	Different awareness control approaches are evaluated by analyzing messages collected during incident detection, while also considering packet losses.	While sensors are useful in supporting safety applications for OM, they are inherently limited	The POSACC control method is an efficient and capable method for detecting unsafe OM in various situation.
21	[58]	Clothoid Tentacles	Using the Clothoid Tentacles method, trajectories for lane change maneuvers are generated, considering vehicle dynamics, traffic rules and some safety measures.	Build an appropriate trajectory for lane change maneuvers, considering the vehicle dynamics and the relevant traffic rules.	The Clothoid Tentacles enable the trajectory to be generated in a single step, which reduces both complexity and computational time.
22	[62]	OP-CAS	A method based on behavioral cloning using images obtained from a low-cost monocular camera is used for the overtaking procedure	To develop a new anti-collision system for Avs that uses a behavioral cloning-based approach and takes images from a low-cost monocular camera.	The results indicated that, by observing two expert drivers executing OM to collect data, even a reduced data set was able to adequately represent the sequence of the OM.
23	[56]	EDSP and FC	Employing a driver assistance system that uses a low-cost embedded digital signal processor for generating decisions and performing driving tasks while OM are being performed.	The need for a driver-assistance system that can facilitate decision making and the performing of driving tasks while executing OM.	The system shows the feasibility of using the coordination strategies involved during the performance of various driving maneuvers.
24	[63]	Swarm intelligence algorithm	The swarm intelligence-based algorithm solves a multi-objective optimal control model in order to optimize the maneuver time duration, the trajectory smoothness, and the vehicle visibility.	Generate overtaking trajectories for AVs.	The algorithm produces optimal multi-objective overtaking trajectories for AVs
25	(Dixit et al., 2020)	MCF and MPC	Identifies safe zones on a highway which the vehicle can navigate towards by using a combination of a potential field like function and reachability sets of a vehicle	Situation control and trajectory planning for autonomous overtaking in high-speed structured environments	The proposed method can be adapted to safety conditions that are generated when performing a high-speed OM. Moreover, the trajectories generated by the algorithm are compatible with the vehicle dynamics.
26	[71]	ANAC	A general kinematic model of the vehicles and the relative intervehicle kinematics during the OM are proposed. In addition, an update control law is designed for the automated vehicle that tracks the desired virtual trajectories in real time.	Lack of a method to perform an autonomous three-phase OM without the need to use a road marking scheme or intervehicle communication.	Designed controller allows tracking of desired virtual trajectories for each phase generated in real time.
27	[78]	FIS and Q-learning framework	A fuzzy inference system (FIS) is used to evaluate vehicle driving actions using relative position data, along with the Q-learning based decision frameworks.	Develop efficient and reliable OM with information on the position of the two vehicles involved during overtaking.	
	Numerical results show that relative position information can execute prudent and aggressive OM.				
28	[66]	BPPA	The planner decides on the vehicle control mode using a road map and perception information. The planner	Planning safe autonomous driving trajectories in structured environments.	Path Planning allows independent design and validation for the vehicle

(*continued on next page*)

(*continued*)

No	Author(s) & year	Method	Methodology	Gap & research problem	Result & Outcome
			also determines the vehicle's acceleration and deceleration control strategy to complete the maneuver.		to follow regulations and perform various maneuvering.
29	[77]	Hierarchical (H-MPC)	The front wheel steering angles are calculated by solving a constrained model predictive control problem, and a feedback mechanism for error correction is introduced in the motion controller.	Maintaining a collision-free trajectory for AVs.	The hierarchical control framework is capable of providing safe and feasible driving maneuvers.
30	[68]	Supervised learning approach	Training data sets are collected by solving optimal control problems and then used to train a neural network.	The need for an efficient and fast approach to reference trajectory planning for AVs in a cooperative environment.	The controller shows high performance while requiring low training effort.
31	(Marcano et al., 2020)	MPC with PD and FIS	A design of ADAS systems that consider the driver in the control cycle is performed. Furthermore, two parameters relevant to the cognitive level of the driving task are designed: the level of haptic authority (LoHA) and the level of shared authority (LoSA).	Design a multivariate decision system by adding the human component.	MPC with PD and FIS controller provide driver assistance benefits during an OM.
32	[72]	Stochastic control	The control algorithm uses the information available from the vehicle ahead which is the relative position, the relative speeds with respect to other cars and its position and past actions. With this information the vehicle decides whether it wants to overtake or not.	Minimize the probability of collision in the vehicle overtaking problem.	The control algorithm minimizes the probability of collision.
33	[69]	Clustering methods and probability density functions	Trajectory generation includes model prediction of surrounding vehicles while a robust Linear Parameter Varying (LPV) control design ensures tracking of the calculated reference.	Determine a hierarchical overtaking strategy, which is a driver assistance function.	Optimal control ensures the safe movement of vehicles and manages interactions with other traffic participants.
34	(J. Hu et al., 2020)	MPC and TRFC	Trajectory generation is based on the safety distance between the leading vehicle and the obstructing vehicle, which is related to traffic and vehicle speed. In addition, model predictive control helps to follow the predicted trajectory.	Develop a trajectory planning and tracking framework.	Path planning and tracking avoids vehicle collisions on a straight one-way, two-lane highway
35	[65]	Spline-based interpolation strategy	The optimization algorithm generates the optimal trajectory considering collision avoidance and comfort objectives.	Determine an effective path planning method for AVs.	The algorithm solves a wide range of traffic scenarios and is suitable for real-time application.
36	(Osman et al., 2020)	Guidance navigation control	Through the combination of navigation guidance and image-based visual detection, road-following and OM are accomplished	Solve critical road following and vehicle overtaking problems.	Guidance navigation control algorithm helps a vehicle's automated driving system maintain safe spacing between vehicles.
37	[73]	MOMDP	MOMDP is used to formulate the overtaking problem on two-way roads and find the optimal strategy considering uncertainties in the problem.	Propose a new formulation for overtaking on two-way roads.	MOMDP improves performance by reducing collision probability and overtaking duration.
38	(Cao et al., 2016)	HP with MPC	Through the integration of different modules such as decision making, route planning, lateral route tracking and a fuzzy adaptive tracking module, complete architecture of an active collision avoidance system is created for an AVs.	The need to develop a trajectory for safe OM to avoid collisions.	The vehicle that performs the OM can carry out the maneuver successfully, thus avoiding collisions without the intervention of a human driver.
39	[76]	FIRL	Using a combination of reinforcement learning and fuzzy logic techniques to make overtaking decisions in AVs, an MDP decision process is formulated and a temporal reinforcement difference learning (DF-TDL) algorithm is used.	Perform intelligent decision control for AVs decisions.	The method makes safe AVs decisions.
40	[75]	Anticipatory kinodynamic motion planner	The planner divides the road space into sections and analyzes each section to find the best route and speed for the vehicle at any given time, considering both static and moving objects on the road.	Improve trajectory and speed profile for autonomous driving in complex dynamic environments.	The planner performs adequately in different situations involving constant changes, managing to maintain a smooth acceleration that contributes to passenger comfort.

(*continued on next page*)

(*continued*)

No	Author(s) & year	Method	Methodology	Gap & research problem	Result & Outcome
41	(Jeon et al., 2022)	FSM and MPC	The OM uses a high-level decision maker based on a finite state machine and a trajectory planner based on model predictive control with chance constraints to improve travel efficiency and driving comfort while ensuring safety.	The challenge of developing an overtaking trajectory planning algorithm that can guarantee safety while maximizing trip efficiency in all situations using one algorithm.	The trajectory planning guarantees greater security than the rule-based algorithm.
42	[74]	HF with FSM	The model uses a motivation layer to select the driving strategy as the driving intention, a decision layer that dynamically adjusts the intention through strategy transition, and an action layer that specifies the decided behavior in control parameters.	The lack of models capable of describing the complex interaction of multiple agents on two-lane two-way urban streets.	.The vehicle can choose the most important action in situations of interaction with multiple elements and carry out the appropriate behavior among several possible alternatives.
43	[79]	CLF and CBF	The approach utilizes a Lyapunov function (CLF) that follows an integrated control barrier function (CBF) and model predictive control (MPC) for performing overtaking maneuvers.	Develop a path-planning approach for autonomous driving that prioritizes safety and comfort, specifically for overtaking maneuvers, while also being efficient and viable.	The results reveal that the devised method has the capability to produce paths that are both optimal and free from collisions, hence guaranteeing secure and smooth driving in complex areas.
44	[84]	System-level framework	The study is centered on the optimization of driving techniques and maneuvers such as overtaking. This includes the development of precise powertrain models tailored to various vehicle categories and the identification of ideal speed and acceleration patterns.	To improve the efficiency of driving a diverse group of vehicles, it is important to take into account the need to overtake.	The results demonstrate that through optimal overtaking strategies, the framework effectively reduces energy consumption and driving delays, offering a comprehensive solution for energy-efficient multi-vehicle driving.
45	[86]	Dual-variable trajectory planning framework	In order to guarantee safety and driving efficiency, the methodology involves the optimization of the optimal trajectory for longitudinal and lateral movements within a decreasing horizon framework, as well as the modeling of collision-free constraints using a dual-variable optimization approach.	There is a lack of real-time safe path planning for autonomous overtaking in dynamic situations.	The proposed method shows effective and secure overtaking by attaining smooth and collision-free paths while keeping driving comfort and efficiency.
46	(G. Li, Zhang, et al., 2023)	Convex Optimization	The study presents a method for planning optimal trajectories in real-time for autonomous driving, which includes collision avoidance. In order to achieve this objective, the trajectory that avoids collisions is defined as a nonlinear optimization problem, and a method for approximation convex optimization is devised.	The research aims to fill the gaps in real-time mobility planning with collision avoidance for autonomous cars in complex urban settings.	The simulation results show the method's ability to handle different driving conditions effectively, producing seamless and collision-free paths while ensuring driving comfort and efficiency.
47	[46]	Field measurements	The study examines the paths taken by vehicles during passing maneuvers through the use of GNSS receivers to collect trajectory data. The primary emphasis is on the sequential reverse curving sections that occur at the initiation and conclusion of overtaking movements.	The research focuses on the lack of standardization in overtaking techniques on rural two-lane roads, which include intricate duties of entering and exiting the incoming lane.	The results yield accurate overtaking trajectories and guiding trajectories for various speed conditions.
48	[80]	Coordinated control design with MPC	The methodology involves integrating ethical considerations into the design of Model Predictive Control (MPC), focusing on clear rules and predictable vehicle movement to enhance trust.	Create a control system that simultaneously maximizes vehicle performance and upholds ethical ideals, guaranteeing safe and reliable operation.	The suggested method successfully integrates ethical concepts into the control design, guaranteeing collision-free travel and adherence to traffic norms.
49	[45]	Passing Sight Distance Using Vehicle Dynamic Response (PSD)	The study assesses the passing visibility distance (PSD) through the use of vehicle dynamics models. The analysis involves a comparison between conventional PSD models and simulated data, while considering factors like as road gradient and tire-road friction.	The objective is to construct a comprehensive PSD model that incorporates criteria aimed at enhancing both road safety and operational performance.	The suggested analytical model has a high level of accuracy, with errors that are limited to within 5 % of the simulated values. Furthermore, it shows superior alignment with empirical data when compared to standard models.
50	[81]	Control barrier functions and MPC	This research presents an efficient system for autonomous vehicle overtaking by utilizing control barrier functions (CBF) and model predictive control (MPC).	Develop a safe overtaking control technique that considers the behavior of both the leading vehicle and the oncoming vehicle.	The results offer robust safety assurances and exceed conventional methods in safety-critical overtaking tasks.
51	[82]	MPC	Use of a dynamic bicycle model to simulate vehicle dynamics.	The study focuses on the lack of current solutions for overtaking	The proposed system is capable of executing safe overtaking maneuvers

(*continued on next page*)

(*continued*)

No	Author(s) & year	Method	Methodology	Gap & research problem	Result & Outcome
			Furthermore, stereo vision and machine learning techniques (YOLO and DeepSORT) are used to collect data about the surrounding environment, including lane width, lane center, and distances from nearby vehicles. Vehicle control during overtaking maneuvers is monitored.	vehicle maneuvers that are based on simplified kinematic models.	while respecting predetermined acceleration, speed, and trajectory constraints, especially when operating at low speed.

References

[1] Z. Xu, K. Zhang, H. Min, Z. Wang, X. Zhao, P. Liu, What drives people to accept automated vehicles? Findings from a field experiment, Transp. Res. Part C: Emerg. Technol. 95 (2018) 320–334, https://doi.org/10.1016/j.trc.2018.07.024.

[2] A. Borowczyk, D.-T. Nguyen, A. Phu-Van Nguyen, D.Q. Nguyen, D. Saussié, J. Le Ny, Autonomous landing of a multirotor micro air vehicle on a high velocity ground vehicle, IFAC-PapersOnLine 50 (1) (2017) 10488–10494, https://doi.org/10.1016/j.ifacol.2017.08.1980.

[3] A. Tsolakis, D. Benders, O. de Groot, R.R. Negenborn, V. Reppa, L. Ferranti, COLREGs-aware trajectory optimization for autonomous surface vessels, IFAC-PapersOnLine 55 (31) (2022) 269–274, https://doi.org/10.1016/j.ifacol.2022.10.441.

[4] C. Garcia-Sanchez, J.A. Lozano, J. Felez, Simulation model for an autonomous truck connected to an ehighway, Simul. Ser. 50 (12) (2018) 60–71.

[5] J.C. Miles, A.J. Walker, The potential application of artificial intelligence in transport, IEE Proc.: Intell. Transp. Syst. 153 (3) (2006), https://doi.org/10.1049/ip-its:20060014.

[6] C. Liu, Y. Chen, J. Chen, R. Payton, M. Riley, S.-H. Yang, Cooperative Perception with Learning-Based V2V Communications, 2023, https://doi.org/10.1109/LWC.2023.3295612.

[7] Y. Mo, R. Vijay, R. Rufus, N.de Boer, J. Kim, M Yu, Enhanced perception for autonomous vehicles at obstructed intersections: an implementation of vehicle to infrastructure (V2I) collaboration, Sensors 24 (3) (2024), https://doi.org/10.3390/s24030936.

[8] S. Šurdonja, T. Giuffrè, A. Deluka-Tibljaš, Smart mobility solutions-necessary precondition for a well-functioning smart city, Transp. Res. Procedia 45 (2019) (2020) 604–611, https://doi.org/10.1016/j.trpro.2020.03.051.

[9] O. Tengilimoglu, O. Carsten, Z. Wadud, Implications of automated vehicles for physical road environment: a comprehensive review, Transp. Res. Part E: Logistic. Transp. Rev. 169 (October 2022) (2023) 102989, https://doi.org/10.1016/j.tre.2022.102989.

[10] B. Vanholme, D. Gruyer, B. Lusetti, S. Glaser, S. Mammar, Highly automated driving on highways based on legal safety, IEEE Trans. Intell. Transp. Systems 14 (1) (2013) 333–347, https://doi.org/10.1109/TITS.2012.2225104.

[11] A. Norouzi, A. Barari, H. Adibi-Asl, Stability control of an autonomous vehicle in overtaking manoeuvre using wheel slip control, Int. J. Intell. Transp. Syst. Res. 18 (2) (2020) 320–330, https://doi.org/10.1007/s13177-019-00200-6.

[12] A. Calvi, F. D'Amico, L.B. Ciampoli, C. Ferrante, Evaluation of driving performance after a transition from automated to manual control: a driving simulator study, Trans. Res. Procedia 45 (2020) 755–762, https://doi.org/10.1016/j.trpro.2020.02.101.

[13] Z. Huang, Q. Wu, J. Ma, S. Fan, An APF and MPC combined collaborative driving controller using vehicular communication technologies, Chaos, Soliton Fractal 89 (2016) 232–242, https://doi.org/10.1016/j.chaos.2015.11.009.

[14] Zolock, J., Senatore, C., Yee, R., Larson, R., & Curry, B. (2016). The use of stationary object radar sensor data from advanced driver assistance systems (ADAS) in accident reconstruction. *SAE Technical Papers*. https://doi.org/10.4271/2016-01-1465.

[15] F. Jiménez, J.E. Naranjo, J.J. Anaya, F. García, A. Ponz, J.M. Armingol, Advanced driver assistance system for road environments to improve safety and efficiency, Transp. Res. Procedia 14 (2016) 2245–2254, https://doi.org/10.1016/j.trpro.2016.05.240.

[16] J. Piao, M. McDonald, Advanced driver assistance systems from autonomous to cooperative approach, Transp. Rev. 28 (5) (2008) 659–684, https://doi.org/10.1080/01441640801987825.

[17] F.M. Favarò, S.O. Eurich, S.S. Rizvi, "Human" problems in semi-autonomous vehicles: understanding drivers' reactions to off-nominal scenarios, Int. J. Hum. Comput. Interact. 35 (11) (2019) 956–971, https://doi.org/10.1080/10447318.2018.1561784.

[18] J.H. Kim, G. Lee, J. Lee, K.F. Yuen, J. Kim, Determinants of personal concern about autonomous vehicles, Cities. 120 (2022), https://doi.org/10.1016/j.cities.2021.103462.

[19] L. Guo, P. Ge, D. Sun, Variable time headway autonomous emergency braking control algorithm based on model predictive control, in: Proceedings - 2020 Chinese Automation Congress, CAC 2020, 2020, pp. 1794–1798, https://doi.org/10.1109/CAC51589.2020.9327238.

[20] B.A. Jumaa, A.M. Abdulhassan, A.M. Abdulhassan, Advanced Driver Assistance System (ADAS): A Review of Systems and Technologies, 2019.

[21] S.Y. Kim, J.K. Kang, S.Y. Oh, Y.W. Ryu, K. Kim, S.C. Park, J. Kim, An intelligent and integrated driver assistance system for increased safety and convenience based on all-around sensing, J. Intell. Robotic Syst.: Theory Appl. 51 (3) (2008) 261–287, https://doi.org/10.1007/s10846-007-9187-0.

[22] H. Lengyel, T. Tettamanti, Z. Szalay, Conflicts of automated driving with conventional traffic infrastructure, IEEe Access. 8 (2020) 163280–163297, https://doi.org/10.1109/ACCESS.2020.3020653.

[23] M. Lu, K. Wevers, R. Van der Heijden, Technical feasibility of advanced driver assistance systems (ADAS) for road traffic safety, Transp. Plan. Technol. 28 (3) (2005) 167–187, https://doi.org/10.1080/03081060500120282.

[24] C. Hu, Y. Qin, H. Cao, X. Song, K. Jiang, J.J. Rath, C. Wei, Lane keeping of autonomous vehicles based on differential steering with adaptive multivariable super-twisting control, Mech. Syst. Signal Process. 125 (2019) 330–346, https://doi.org/10.1016/j.ymssp.2018.09.011.

[25] B. Jiang, X. Li, Y. Zeng, D. Liu, A maneuver evaluation algorithm for lane-change assistance system, Electronics (Switzerland) 10 (7) (2021), https://doi.org/10.3390/electronics10070774.

[26] S. Maadi, S. Stein, J. Hong, R. Murray-Smith, Real-time adaptive traffic signal control in a connected and automated vehicle environment: optimisation of signal planning with reinforcement learning under vehicle speed guidance, Sensors 22 (19) (2022), https://doi.org/10.3390/s22197501.

[27] L. Miao, D. Leitner, Adaptive traffic light control with quality-of-service provisioning for connected and automated vehicles at isolated intersections, IEEe Access. 9 (2021) 39897–39909, https://doi.org/10.1109/ACCESS.2021.3064310.

[28] M. Alawadhi, J. Almazrouie, M. Kamil, K.A. Khalil, A systematic literature review of the factors influencing the adoption of autonomous driving, in: , 2020, https://doi.org/10.1007/s13198-020-00961-4.

[29] F. Duarte, C. Ratti, The impact of autonomous vehicles on cities: a review, J. Urban. Technol. 25 (4) (2018) 3–18, https://doi.org/10.1080/10630732.2018.1493883.

[30] E. Martí, M.Á. De Miguel, F. García, J. Pérez, A review of sensor technologies for perception in automated driving, IEEE Intell. Transp. Syst. Mag. 11 (4) (2019) 94–108, https://doi.org/10.1109/MITS.2019.2907630.

[31] J. Palatti, A. Aksjonov, G. Alcan, V. Kyrki, Planning for safe abortable overtaking maneuvers in autonomous driving, in: *2021 IEEE International Intelligent Transportation Systems Conference (ITSC), 2021-Septe*(August), 2021, pp. 508–514, https://doi.org/10.1109/ITSC48978.2021.9564499.

[32] K. Anindyaguna, N.C. Basjaruddin, D. Saefudin, Overtaking assistant system (OAS) with fuzzy logic method using camera sensor, in: 2016 2nd International Conference of Industrial, Mechanical, Electrical, and Chemical Engineering, ICIMECE 2016, 2017, pp. 89–94, https://doi.org/10.1109/ICIMECE.2016.7910420.

[33] X. Zhang, J. Tao, K. Tan, M. Törngren, J.M.G. Sánchez, M.R. Ramli, X. Tao, M. Gyllenhammar, F. Wotawa, N. Mohan, M. Nica, H. Felbinger, Finding Critical Scenarios For Automated Driving Systems: A Systematic Literature Review, 2021, pp. 1–37.

[34] D. Nalic, T. Mihalj, A. Eichberger, M. Bäumler, M. Lehmann, Scenario Based Testing of Automated Driving Systems: A Literature Survey, 2022, https://doi.org/10.46720/f2020-acm-096. *October*.

[35] L. Prochowski, P. Szwajkowski, Measurement Systems Used in Experiments, 2022.

[36] M.J. Page, J.E. McKenzie, P.M. Bossuyt, I. Boutron, T.C. Hoffmann, C.D. Mulrow, L. Shamseer, J.M. Tetzlaff, E.A. Akl, S.E. Brennan, R. Chou, J. Glanville, J. M. Grimshaw, A. Hróbjartsson, M.M. Lalu, T. Li, E.W. Loder, E. Mayo-Wilson, S. McDonald, D. Moher, The PRISMA 2020 statement: an updated guideline for reporting systematic reviews, The BMJ 372 (2021), https://doi.org/10.1136/bmj.n71.

[37] A. Liberati, D.G. Altman, J. Tetzlaff, C. Mulrow, P.C. Gøtzsche, J.P.A. Ioannidis, M. Clarke, P.J. Devereaux, J. Kleijnen, D. Moher, The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration, BMJ 339 (2009), https://doi.org/10.1136/bmj.b2700.

[38] R. Sarkis-Onofre, F. Catalá-López, E. Aromataris, C. Lockwood, How to properly use the PRISMA statement, Syst Rev 10 (1) (2021) 13–15, https://doi.org/10.1186/s13643-021-01671-z.

[39] C.A.B. Nielsen, L. Lönn, L. Konge, M. Taudorf, Simulation-based virtual-reality patient-specific rehearsal prior to endovascular procedures: a systematic review, Diagnostics 10 (7) (2020) 1–12, https://doi.org/10.3390/diagnostics10070500.
[40] M. Regona, T. Yigitcanlar, B. Xia, R.Y.M. Li, Opportunities and adoption challenges of AI in the construction industry: a PRISMA review, J. Open Innovat.: Technol. Market Complexity 8 (1) (2022) 45, https://doi.org/10.3390/joitmc8010045.
[41] S.A. Kaye, K. Somoray, D. Rodwell, I. Lewis, Users' acceptance of private automated vehicles: a systematic review and meta-analysis, J. Saf. Res. 79 (2021) 352–367, https://doi.org/10.1016/j.jsr.2021.10.002.
[42] M.B. Bouraima, P.K. Alimo, S. Agyeman, P.D. Sumo, G. Lartey-Young, D. Ehebrecht, Y. Qiu, Africa's railway renaissance and sustainability: current knowledge, challenges, and prospects, J. Transp. Geogr. 106 (2023), https://doi.org/10.1016/j.jtrangeo.2022.103487. Elsevier Ltd.
[43] G. Demir, P. Chatterjee, D. Pamucar, Sensitivity analysis in multi-criteria decision making: a state-of-the-art research perspective using bibliometric analysis, Expert Syst. Appl. 237 (2024), https://doi.org/10.1016/j.eswa.2023.121660.
[44] S. Moslem, M.K. Saraji, A. Mardani, A. Alkharabsheh, S. Duleba, D. Esztergar-Kiss, A systematic review of analytic hierarchy process applications to solve transportation problems: from 2003 to 2019, IEEe Access. XX (2023) 1, https://doi.org/10.1109/access.2023.3234298, 1.
[45] A. Raj, P. Deshpande, B.R. Chilukuri, S.C. Subramanian, Analysis and modelling of passing sight distance using vehicle dynamic response, IEEe Access. 11 (2023) 98500–98515, https://doi.org/10.1109/ACCESS.2023.3312028.
[46] S. Mavromatis, V. Matragos, N. Trantas, K. Apostoleris, Modelling passing paths trajectories through field measurements, Transp. Res. Procedia 72 (2023) 3809–3816, https://doi.org/10.1016/j.trpro.2023.11.507.
[47] X. Huang, W. Zhang, P. Li, A path planning method for vehicle overtaking maneuver using sigmoid functions, IFAC-PapersOnLine 52 (8) (2019) 73–80, https://doi.org/10.1016/j.ifacol.2019.08.098.
[48] B. Vigne, R. Orjuela, J.-P. Lauffenburger, M. Basset, A personalized path generation for an autonomous vehicle overtaking maneuver, IFAC-PapersOnLine 55 (14) (2022) 107–112, https://doi.org/10.1016/j.ifacol.2022.07.591.
[49] J. Ortega, H. Lengyel, J. Ortega, Design and analysis of the trajectory of an overtaking maneuver performed by autonomous vehicles operating with advanced driver-assistance systems (ADAS) and driving on a highway, Electronics (Basel) 12 (1) (2022) 51, https://doi.org/10.3390/electronics12010051.
[50] J. Ortega, H. Lengyel, Z. Szalay, Overtaking maneuver scenario building for autonomous vehicles with PreScan software, Transp. Eng. 2 (December) (2020) 100029, https://doi.org/10.1016/j.treng.2020.100029.
[51] Ľ. Magdolen, J. Danko, T. Milesich, I. Kevický, M. Galinský, J. Bucha, R. Skyrčák, Virtual simulation of overtaking maneuver of autonomous vehicle, Strojnicky Casopis 71 (2) (2021) 179–188, https://doi.org/10.2478/scjme-2021-0028.
[52] U. Ghumman, H. Jabbar, M.I. Tiwana, I.U. Khalil, F. Kunwar, A novel approach of overtaking maneuvering using modified RG method, PLoS ONE 17 (1) (2022) e0260455, https://doi.org/10.1371/journal.pone.0260455.
[53] G. Usman, F. Kunwar, Autonomous vehicle overtaking- an online solution, in: 2009 IEEE International Conference on Automation and Logistics, 2009, pp. 596–601, https://doi.org/10.1109/ICAL.2009.5262854.
[54] J.E. Naranjo, C. González, R. García, T. De Pedro, Lane-change fuzzy control in autonomous vehicles for the overtaking maneuver, IEEE Trans. Intell. Transp. Syst. 9 (3) (2008) 438–450, https://doi.org/10.1109/TITS.2008.922880.
[55] J. Pérez, V. Milanés, E. Onieva, J. Godoy, J. Alonso, Longitudinal fuzzy control for autonomous overtaking, in: 2011 IEEE International Conference on Mechatronics, ICM 2011 - Proceedings, 2011, pp. 188–193, https://doi.org/10.1109/ICMECH.2011.5971279.
[56] H.-H. Chiang, Y.-L. Chen, B.-F. Wu, T.-T. Lee, Embedded driver-assistance system using multiple sensors for safe overtaking maneuver, IEEe Syst. J. 8 (3) (2014) 681–698, https://doi.org/10.1109/JSYST.2012.2212636.
[57] V. Milanés, D.F. Llorca, J. Villagrá, J. Pérez, C. Fernández, I. Parra, C. González, M. A. Sotelo, Intelligent automatic overtaking system using vision for vehicle detection, Expert Syst. Appl. 39 (3) (2012) 3362–3373, https://doi.org/10.1016/j.eswa.2011.09.024.
[58] C. Alia, T. Reine, C. Ali, Maneuver planning for autonomous vehicles, with clothoid tentacles for local trajectory planning, in: *2017 IEEE 20th International Conference on Intelligent Transportation Systems (ITSC), 2018-March*, 1–6, 2017, https://doi.org/10.1109/ITSC.2017.8317856.
[59] S. Bansal, F. Alimardani, J.S. Baras, Model-based systems engineering applied to the trajectory planning for autonomous vehicles, in: 2018 IEEE International Systems Engineering Symposium (ISSE), 2018, pp. 1–8, https://doi.org/10.1109/SysEng.2018.8544452.
[60] H. Bhuiyan, G. Governatori, A. Bond, A. Rakotonirainy, Validation of autonomous vehicle overtaking under queensland road rules, in: CEUR Workshop Proceedings 3229, 2022.
[61] S. Bolufe, C.A. Azurdia-Meza, S. Cespedes, S. Montejo-Sanchez, Impact of awareness control on V2V-based overtaking application in autonomous driving, IEEE Commun. Lett. 25 (4) (2021) 1373–1377, https://doi.org/10.1109/LCOMM.2020.3044734.
[62] E.S. Cha, K.-E. Kim, S. Longo, A. Mehta, OP-CAS: collision avoidance with overtaking maneuvers, in: *IEEE Conference on Intelligent Transportation Systems, Proceedings, ITSC, 2018-Novem*, 2018, pp. 1715–1720, https://doi.org/10.1109/ITSC.2018.8569740.
[63] R. Chai, A. Tsourdos, A. Savvaris, S. Chai, Y. Xia, C.L. Philip Chen, Multiobjective Overtaking Maneuver Planning for Autonomous Ground Vehicles, IEEE Trans. Cybern. 51 (8) (2021) 4035–4049, https://doi.org/10.1109/TCYB.2020.2973748.
[64] D.M. Costescu, Autonomous vehicles' safety in mixed traffic: accounting for incoming vehicles when overtaking, in: 2019 Electric Vehicles International Conference (EV), 2019, pp. 1–5, https://doi.org/10.1109/EV.2019.8893110.
[65] C. Götte, M. Keller, T. Nattermann, C. Haß, K.-H. Glander, T. Bertram, Spline-based motion planning for automated driving, IFAC-PapersOnLine 50 (1) (2017) 9114–9119, https://doi.org/10.1016/j.ifacol.2017.08.1709.
[66] J. Kim, K. Jo, D. Kim, K. Chu, M. Sunwoo, Behavior and path planning algorithm of autonomous vehicle A1 in structured environments, IFAC Proc. Vol. 46 (10) (2013) 36–41, https://doi.org/10.3182/20130626-3-AU-2035.00053.
[67] X. Li, X. Qiu, J. Wang, Y. Shen, A deep reinforcement learning based approach for autonomous overtaking, in: 2020 IEEE International Conference on Communications Workshops (ICC Workshops, 2020, pp. 1–5, https://doi.org/10.1109/ICCWorkshops49005.2020.9145279.
[68] L. Markolf, J. Eilbrecht, O. Stursberg, Trajectory planning for autonomous vehicles combining nonlinear optimal control and supervised learning, IFAC-PapersOnLine 53 (2) (2020) 15608–15614, https://doi.org/10.1016/j.ifacol.2020.12.2495.
[69] B. Németh, P. Gaspar, T. Hegedus, B. Németh, P. Gáspár, T. Hegeds, B. Nemeth, P. Gaspar, T. Hegedus, B. Németh, P. Gáspár, T. Hegeds, Optimal control of overtaking maneuver for intelligent vehicles, J. Adv. Transp. 2018 (2018), https://doi.org/10.1155/2018/2195760.
[70] N.A. Othman, U. Reif, A. Ramli, M.Y. Misro, Manoeuvring speed estimation of a lane-change system using geometric hermite interpolation, Ain Shams Eng. J. 12 (4) (2021) 4015–4021, https://doi.org/10.1016/j.asej.2021.02.027.
[71] P. Petrov, F. Nashashibi, Modeling and nonlinear adaptive control for autonomous vehicle overtaking, IEEE Trans. Intell. Transp. Syst. 15 (4) (2014) 1643–1656, https://doi.org/10.1109/TITS.2014.2303995.
[72] A. Raghavan, J. Wei, J.S. Baras, K.H. Johansson, Stochastic control formulation of the car overtake problem, IFAC-PapersOnLine 51 (9) (2018) 124–129, https://doi.org/10.1016/j.ifacol.2018.07.021.
[73] V. Sezer, Intelligent decision making for overtaking maneuver using mixed observable Markov decision process, J. Intell. Transp. Syst. 22 (3) (2018) 201–217, https://doi.org/10.1080/15472450.2017.1334558.
[74] J. Sun, H. Liu, Z. Ma, Modelling and simulation of highly mixed traffic flow on two-lane two-way urban streets, Simul. Model. Pract. Theory. 95 (2019) 16–35, https://doi.org/10.1016/j.simpat.2019.04.005.
[75] J.P. Talamino, A. Sanfeliu, Anticipatory kinodynamic motion planner for computing the best path and velocity trajectory in autonomous driving, Rob. Auton. Syst. 114 (2019) 93–105, https://doi.org/10.1016/j.robot.2018.11.022.
[76] Q. Wu, S. Cheng, L. Li, F. Yang, L.J. Meng, Z.X. Fan, H.W. Liang, A fuzzy-inference-based reinforcement learning method of overtaking decision making for automated vehicles, Proc. Inst. Mech. Eng., Part D: J. Automobile Eng. 236 (1) (2022) 75–83, https://doi.org/10.1177/09544070211018099.
[77] Y. Xu, H. Zheng, W. Wu, J. Wu, Robust hierarchical model predictive control for trajectory tracking with obstacle avoidance, IFAC-PapersOnLine 53 (2) (2020) 15745–15750, https://doi.org/10.1016/j.ifacol.2020.12.056.
[78] M. Zhang, T. Zhang, Q. Zhang, An autonomous overtaking maneuver based on relative position information, in: *2018 IEEE 88th Vehicular Technology Conference (VTC-Fall), 2018-Augus*, 2018, pp. 1–6, https://doi.org/10.1109/VTCFall.2018.8690798.
[79] Y. Ding, H. Zhong, Y. Qian, L. Wang, Y. Xie, Lane-change collision avoidance control for automated vehicles with control barrier functions, Int. J. Automot. Technol. 24 (3) (2023) 739–748, https://doi.org/10.1007/s12239-023-0061-2.
[80] B. Németh, Coordinated control design for ethical maneuvering of autonomous vehicles, Energies. (Basel) 16 (10) (2023), https://doi.org/10.3390/en16104254.
[81] D. Yuan, X. Yu, S. Li, X. Yin, Safe-by-construction autonomous vehicle overtaking using control barrier functions and model predictive control, Int. J. Syst. Sci. 55 (7) (2024) 1283–1303, https://doi.org/10.1080/00207721.2024.2304665.
[82] I. Lamouik, A. Yahyaouy, M.A. Sabri, Model predictive control for full autonomous vehicle overtaking, Transp. Res. Rec. (2023), https://doi.org/10.1177/03611981221141432.
[83] G. Li, H. Guo, Z. Wang, M. Wang, Online trajectory optimization for safe autonomous overtaking with active obstacle avoidance, Rob. Auton. Syst. 169 (2023), https://doi.org/10.1016/j.robot.2023.104528.
[84] M.J. Jung, J. Kim, S.-G. Lee, D. Baek, Energy-efficient driving scheduling for heterogeneous electric vehicles with consideration of overtaking, Energy Rep. 9 (2023) 2348–2358, https://doi.org/10.1016/j.egyr.2023.01.038.
[85] W. Ben-Messaoud, M. Basset, J.-P. Lauffenburger, R. Orjuela, Smooth obstacle avoidance path planning for autonomous vehicles, in: 2018 IEEE International Conference on Vehicular Electronics and Safety (ICVES), 2018, pp. 1–6, https://doi.org/10.1109/ICVES.2018.8519525.
[86] G. Li, X. Zhang, H. Guo, B. Lenzo, N. Guo, Real-time optimal trajectory planning for autonomous driving with collision avoidance using convex optimization, Automot. Innov. 6 (3) (2023) 481–491, https://doi.org/10.1007/s42154-023-00222-7.