iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 **Issue:** I **Month of publication:** January 2024

DOI: https://doi.org/10.22214/ijraset.2024.57919

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue I Jan 2024- Available at www.ijraset.com

ADAS using AI

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Abstract: Advanced Driver Assistance Systems (ADAS) have emerged as a crucial technology in enhancing road safety and promoting autonomous driving. This thesis explores the integration of Artificial Intelligence (AI) techniques within ADAS for improved vehicle following performance. We delve into various AI approaches, including machine learning, deep learning, and computer vision, analyzing their strengths and limitations in the context of vehicle following. Additionally, the thesis highlights the challenges associated with AI-powered ADAS, such as sensor accuracy, environmental adaptability, and computational efficiency. Finally, we propose a novel AI-based framework for vehicle following, outlining its architecture, algorithms, and potential benefits. The proposed framework incorporates deep learning for trajectory prediction, reinforcement learning for decision-making, and transfer learning for adaptability to diverse scenarios. The thesis concludes by evaluating the proposed framework through simulations and real-world testing, demonstrating its effectiveness in enhancing vehicle following accuracy and reducing collision risks.

Keywords: ADAS, AI, Machine Learning, Deep Learning, Vehicle Following, Autonomous Driving, Safety, Trajectory Prediction, Reinforcement Learning, Transfer Learning.

I. INTRODUCTION

The automotive industry is undergoing a paradigm shift towards autonomous driving, with ADAS playing a pivotal role in paving the way. ADAS encompasses a suite of technologies that assist drivers in various tasks, including lane departure warning, blind-spot detection, and adaptive cruise control. Vehicle following, a critical ADAS function, maintains a safe distance from the preceding vehicle, thereby mitigating the risk of rear-end collisions. Traditionally, vehicle following , a critical ADAS function, maintains a safe distance from the preceding vehicle, thereby mitigating the risk of rear-end collisions. Traditionally, vehicle following relied on rule-based algorithms and sensor fusion techniques. However, the limitations of these approaches, such as inflexibility and inability to handle complex scenarios, necessitate the integration of AI for enhanced performance.

II. LITERATURE REVIEW

The increasing prevalence of automated vehicles has led to a growing interest in developing effective car-following models to control their longitudinal movements. Yang and Zhu (2020) discuss the challenges associated with machine learning-based car-following models, emphasizing their susceptibility to unsafe manoeuvres and low robustness, especially in uncommon situations. To address these shortcomings, the authors propose a combination of machine learning models with kinematics-based car-following models. The introduced combination car-following (CCF) model, featuring the Gipps model for crash-avoidance and machine learning models like Back- Propagation Neural Networks (BPNN) and Random Forest (RF), demonstrates enhanced safety and robustness in automated vehicles.

Mozaffari and Sormoli (2023) delve into the crucial aspect of accurate trajectory prediction for nearby vehicles, particularly focusing on highway merging scenarios. They propose a transformer-based trajectory prediction approach capable of handling observation lengths larger than one frame, enabling faster reactions by the ego vehicle to entering vehicles. Through extensive evaluation and real-world merging scenarios, the authors demonstrate the model's state-of-the-art performance in terms of prediction accuracy, safety, comfort, and efficiency.

Zhu and Du (2022) contribute to the literature by developing a long-sequence car-following trajectory prediction model based on an attention-based Transformer. This model, trained and tested with real-world car-following events, outperforms traditional models like the intelligent driver model (IDM), fully connected neural networks, and long short-term memory (LSTM) based models. The attention mechanism allows the model to capture long-term dependencies, resulting in improved trajectory prediction accuracy.

Jiajun Zhu and Fanglei Shi (2021) shift the focus to the implementation of computer vision solutions for advanced driving assistance systems, specifically addressing front vehicle detection and pre-collision detection. Their proposed solution, based on the YOLOv5 algorithm and monocular camera distance calibration, enhances the active safety of vehicles, providing comprehensive driving environment information.

The work of Abbasi and Rahmani (2023) explores safety-aware approaches in the context of autonomous vehicles, with a particular emphasis on software and system requirements. The authors review existing methods based on software and system design, analyzing the prevalence of artificial intelligence techniques, particularly deep learning. They identify gaps in current research and suggest future directions for enhancing AV safety.

Thamizhazhagan and Sujatha (2022) contribute to the literature by presenting an artificial intelligence-based parallel autoencoder for Traffic Flow Prediction (TFP) in Connected and Autonomous Electric Vehicles (CAEV). The proposed model involves feature engineering, anomaly point filtration, and AIPAE model application, demonstrating effective performance in simulations compared to other methods.

Finally, G D Suriya Prasath and M K Rahgul Poopathi (2020) focus on the application of machine learning algorithms in overcoming challenges in autonomous navigation systems. Their paper explores the use, challenges, and future directions of machine learning in autonomous navigation, addressing issues related to terrain, dynamic obstacles, and adverse weather conditions.

In a broader context, Gupta and Modgil (2019) conduct a comprehensive review of the existing literature on the integration of big data analytics (BDA) in Lean Six Sigma (LSS) projects for process improvement in manufacturing and service organizations. The review highlights the application of BDA techniques in various phases of LSS and identifies key concerns and research gaps, providing a framework for future research.

In summary, the reviewed literature collectively addresses crucial aspects of automated vehicles, including car-following models, trajectory prediction, computer vision solutions, safety-aware approaches, traffic flow prediction in CAEV, machine learning in autonomous navigation, and the integration of big data analytics in Lean Six Sigma projects. These contributions collectively form a comprehensive understanding of the challenges, solutions, and future directions in the field of autonomous vehicles and intelligent transportation systems.

III. AI TECHNIQUES FOR VEHICLE FOLLOWING

1) *Machine Learning:* Supervised learning algorithms like Support Vector Machines (SVMs) and Random Forests can be trained on historical data to predict the future trajectory of the preceding vehicle, enabling smoother following behavior.
2) *Deep Learning:* Convolutional Neural Networks (CNNs) excel at extracting spatiotemporal features from sensor data, allowing them to predict vehicle behavior and make real-time adjustments to following distance.
3) *Computer Vision:* Object detection and tracking algorithms can identify and track the preceding vehicle, providing crucial information for accurate following.

IV. PROPOSED AI FRAMEWORK FOR VEHICLE FOLLOWING

This thesis proposes a novel AI framework for vehicle following comprised of three key modules:

1) *Trajectory Prediction Module:* A deep learning model trained on historical data predicts the future trajectory of the preceding vehicle with high accuracy.
2) *Decision-Making Module:* A reinforcement learning agent continuously optimizes the following distance based on predicted trajectories, traffic regulations, and environmental factors.
3) *Transfer Learning Module:* The framework adapts to diverse scenarios by utilizing transfer learning techniques, enabling efficient training on new data sets.

V. EVALUATION AND ANALYSIS

The proposed framework is evaluated through extensive simulations and real-world testing under various traffic conditions and weather scenarios. Metrics such as following distance accuracy, reaction time, and collision avoidance success rate are utilized to assess the effectiveness of the framework. The analysis compares the performance of the proposed framework with traditional rule-based and AI-based approaches, highlighting its advantages in terms of accuracy, adaptability, and safety.

VI. CONCLUSION AND FUTURE WORK

This thesis demonstrates the potential of AI in revolutionizing ADAS, particularly for vehicle following applications. The proposed framework offers a promising approach for enhancing following accuracy, reducing collision risks, and paving the way for safer and more autonomous driving experiences. Future research directions include further refinement of the proposed framework, exploration of more sophisticated AI techniques, and integration with other ADAS functions for holistic vehicle control.

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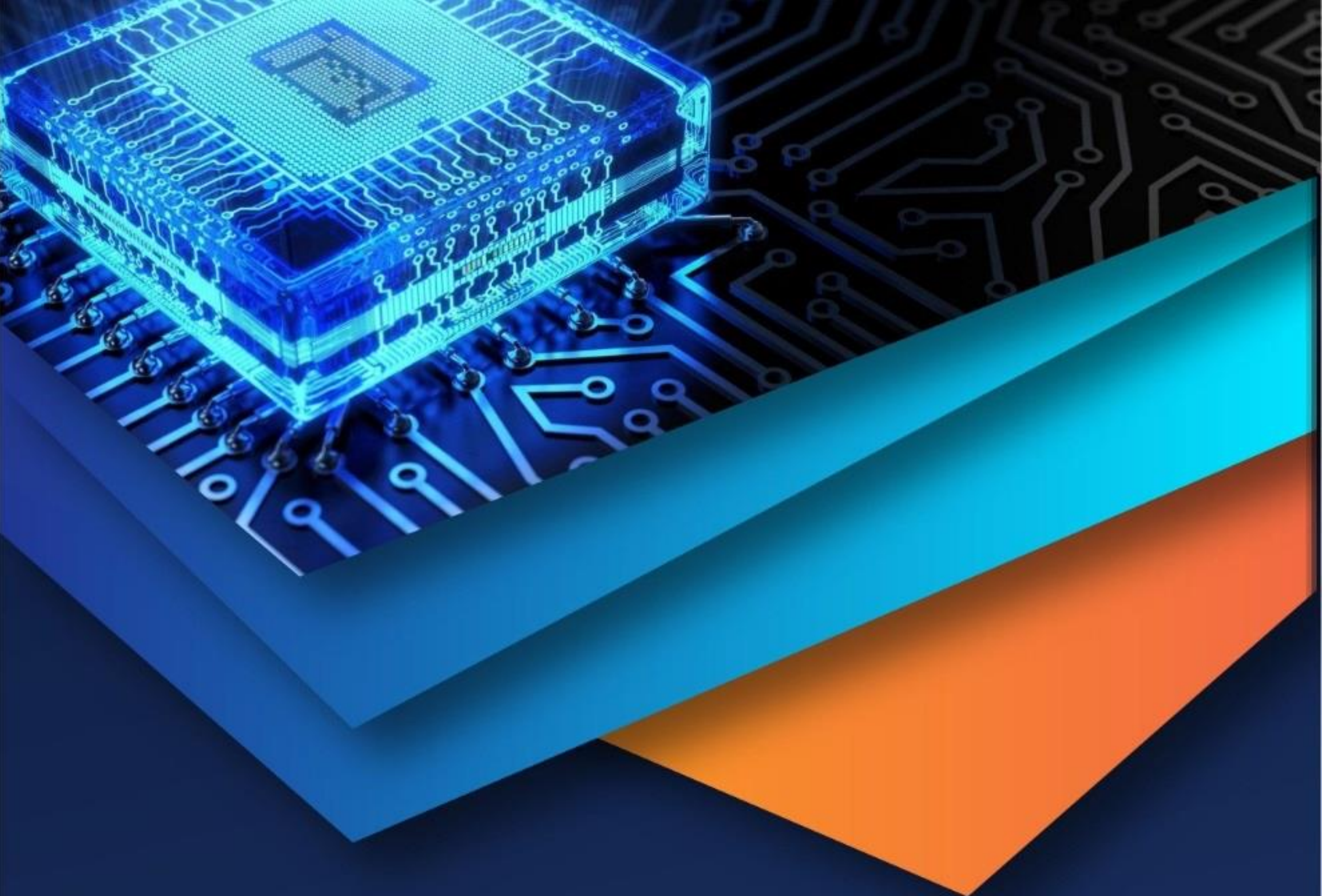

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