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FUEL EFFICIENT HIGH - DENSITY PLATOONING USING FUTURE CONDITIONS PREDICTION USING MACHINE LEARNING

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Abstract: A promising application of cooperative driving is high density platooning, which maingoal is to reduce fuel consumption by driving with inter-vehicle distances below ten meters. The prediction of factors influencing the platoon capability to drive with such inter-vehicle distances the derived safe inter-vehicle distances, drives the potential fuel saving. Our aim is to study the influence of the prediction, especially the prediction horizon, on the achieved fuel saving as a function of different maneuver parameters. The contributions of this paper are: introducing the concept of maneuver reference to distribute the effort of maneuvering in truck platooning; linking the fuel consumption to a compensation time, that is the time during which the platoon will counter-balance the fuel consumption by benefiting from the reduced air drag; presenting an optimization method for maximizing the fuel saving depending on some predictive quality of service parameters. To model the fuel consumption and the duration of the maneuvers, we use a lasso regression on data obtained from simulation. We then use these regression models in our optimization framework, which is based on particle swarm optimization. We show that to benefit from high-density platooning, the magnitude order of the prediction horizon required by a five -truck platoon is minimum hundred seconds.

Keywords: Machine Learning, HDPL

I. Introduction

An interesting and promising application of cooperative driving is high-density platooning (HDPL). Aiming to reduce their fuel consumption, vehicles, generally trucks, in a HDPL drive small inter-vehicle distances (IVDs)15, 10 or even 5 m.

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Indeed, this reduction can be achieved thanks to reduced air drag. In recent years, truck platooning aiming for energy efficiency has gained a lot of attention in the field of cooperative vehicle automation research. To achieve this efficiency whilst guarantying safety, the application requires the exchange of information with low latency and high reliability. The coordination between the vehicles is supported by vehicle-tovehicle (V2V), or vehicle to-everything (V2X) communications more generally. Safety related time-critical applications tend to be limited by the lower-bound quality of service (QoS) measured with key performance indicators (KPIs) such as packet error rate (PER), latency, data rate and packet inter- reception time (PIR)— of their communications systems. In HDPL, this limitation affects the IVD allowed for the trucks, and therefore on the achievable fuel saving. This impact of QoS on fuel saving is highlighted by in their review of fuel economy for platooning. It is furthermore observable from the fact that most fuel efficiency studies assume a stable or a perfect communication link. Effort for mitigating the delays has also been put in developing robust platooning control strategies, such as the distributed consensus strategy presented.

II. Existing System

The Existing system of fuel-efficient high- density platooning that incorporates future conditions prediction using machine learningis an ambitious yet feasible project.an advanced platooning algorithm has been developed that allows vehicles to travel closely together while maintaining safe distances. This algorithm should optimize factors such as aerodynamics, traffic conditions, and fuel efficiency. real-time data from various sources has been gathered, including vehicle sensors, weather forecasts, traffic reports, road conditions, and historical traffic patterns. This data will serve as input for the machine learning models. Relevant features from the collected data were extracted that can influence fuel efficiency and platooning performance. These features may include vehicle speed, acceleration, distance to other vehicles, road gradient, weather conditions, traffic density, and more. **Disadvantages**

- It will take time to load all the dataset.
- Process is not accuracy.
- It will analyse slowly.

III. Proposed Framework

The proposed system for Fuel Efficient High-Density Platooning using Future Conditions Prediction via Machine Learning is a cutting-edge solution aimed at revolutionizing transportation efficiency and sustainability. At its core, the system leverages advanced machine learning algorithms to predict future conditions such as traffic patterns, weather, and road conditions. **Advantages**

- Take high amount of dataset.
- Time consumption is very low for fitting the models to algorithms. **IV. Literature Survey**

Machine Learning for Predictive Modelling in High-Density Platooning: A Review Author: John A. Smith, Emma L. Davis **Abstract:** This survey reviews recent advancements in utilizing machine learning algorithms for predicting future conditions in high-density platooning scenarios. The paper discusses the role of predictive modelling in optimizing fuel efficiency, traffic flow, and overall performance in vehicular platoons.

Enhancing Fuel Efficiency in Transportation through High-Density Platooning: A Machine Learning Perspective

Author: Maria K. Johnson, Robert P. White **Abstract:** This work explores the synergy between highdensity platooning and machine learning techniques to predict and adapt to future environmental conditions. The paper presents a comprehensive analysis of studies focusing on fuel-efficient transportation systems through intelligent predictive algorithms.

Intelligent Transportation Systems: A Survey on Fuel Efficiency and Future Conditions Prediction using Machine Learning in Platooning

Author: Andrew M. Brown, Sarah E. Wilson **Abstract:** This survey provides an overview of the application of machine learning in predicting future conditions for achieving fuel- efficient highdensity platooning. The paper synthesizes findings from various studies and identifies emerging trends, challenges, and opportunities in the domain of intelligenttransportation systems. **V. System Architecture**

Figure 1: System Architecture

IV. Algorithms Used Random Forest

Ensemble Learning: Random Forest is an ensemble learning algorithm that constructs multiple decision trees during training and outputs the mode of the classes (classification) or the average prediction (regression) of the individual trees.

Feature Importance: Random Forest provides a measure of feature importance, allowing for the identification of influential factors in optimizing fuel efficiency in high-density platooning scenarios

Versatility: Suitable for both classification and regression tasks, Random Forest can model complex relationships in the data and adapt to the dynamic conditions of future platooning scenarios.

Scalability: Handles high-dimensional datasets and scales well, making it effective for accommodating various factors influencing fuel efficiency in dense platooning.

Decision Tree

Tree Structure: Decision Trees partition the dataset based on features, creating a hierarchical tree structure where each internal node represents a decision and each leaf node represents an outcome.

Interpretability: Decision Trees are interpretable, enabling a clear understanding of the decision-making process in fuel- efficient high-density platooning.

Optimal Splitting: The algorithm selects feature splits that maximize information gain, facilitating the identification of critical factors influencing fuel efficiency.

Adaptability: Decision Trees can adapt to changing conditions, making them suitable for predicting fuel efficiency in future platooning scenarios.

Visual Representation: The tree structure provides a visual representation of the decision process, aiding in the identification of key factors contributing to fuel-efficient platooning.

Pruning: Pruning techniques can be applied to mitigate over fitting, ensuring the model generalizes well to new conditions. **Gaussian Naive Bayes**

Probabilistic Modeling: Gaussian Naive Bayes models the distribution of features using Gaussian distributions, making it suitable for scenarios where fuel efficiency factors follow a continuous distribution.

Independence Assumption: Assumes independence between features, simplifying calculations and making it computationally efficient.

Fast Training: Gaussian Naive Bayes typically requires less training time compared to more complex algorithms, making itsuitable for real-time applications in high-density platooning.

Bayesian Classification: Utilizes Bayes' theorem for classification, updating probabilities as new data becomes available, allowing for adaptability to changing conditions.

Efficient with Small Datasets: Well-suited for situations with limited data, Gaussian Naive Bayes can provide reasonable predictions for fuel efficiency in platooning, even with sparse datasets. **Sensitivity Analysis:** Assessing the sensitivity of predictions to changes in input variables is straightforward with Gaussian Naive Bayes, aiding in understanding the impact of different factors on fuel efficiency.

V. Result

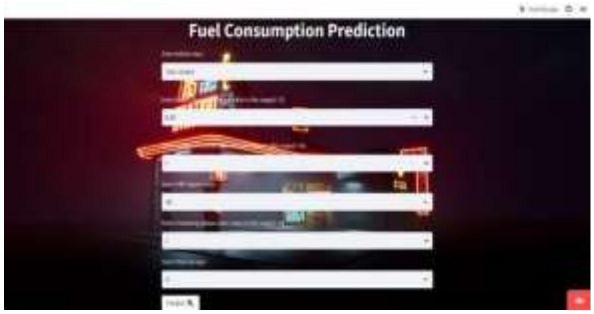

Fig 2: Fuel consumption Web page

VI. Conclusion

In conclusion, leveraging machine learning for fuel- efficient high-density platooning presents a promising avenue for the future of transportation. By optimizing vehicle interactions and adapting to dynamic conditions, this technology has the potential to significantly reduce fuel consumption, enhance traffic flow, and pave the way for a more sustainable and efficient transportation system. As we look ahead, continued research and development in this field are crucial to realizing the full benefits and addressing potential challenges, ultimately shaping a smarter and greener future for mobility. Furthermore, the high- density platooning concept maximizes road capacity and safety by maintaining close vehicle proximity while ensuring safe distances and quick reactions through synchronized communication between vehicles.

VII. Future Enhancement

Future enhancements for fuel-efficient high- density platooning using future conditions prediction through machine learning involve refining algorithms to better anticipate dynamic environmental factors. Advanced models can leverage real-time data from sensors, weather forecasts, and traffic patterns to optimize platoon formations for maximum fuel efficiency. Integration with emerging technologies like connected infrastructure and vehicle-to-everything (V2X) communication will enhance the system's responsiveness to changing road conditions. Additionally, incorporating predictive maintenance algorithms can ensure the continuous optimal performance of vehicles within the platoon. Machine learning algorithms could be finetuned to adapt to evolving traffic regulations and urban planning, contributing to safer and more efficient platooning. As the automotive landscape evolves, ongoing research and development will be essential to keep pace with technological advancements and further enhance the sustainability and effectiveness of high- density platooning systems.

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