

A Predictive Machine Learning Approach for Autonomous Vehicle Driving Decisions

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Abstract: Autonomous vehicles require intelligent decision-making systems to ensure safe, efficient, and reliable driving in dynamic traffic environments. Traditional autonomous driving approaches primarily rely on external factors such as road conditions, traffic flow, and the behavior of surrounding vehicles. However, these methods often overlook the influence of internal vehicle parameters that can significantly impact driving performance and decision quality. To address this limitation, this study proposes an Intelligent Driving Decision Strategy (DDS) based on Machine Learning for autonomous vehicles. The proposed DDS framework integrates both internal and external driving factors to generate optimal driving decisions in real time. Sensor data collected from the vehicle and its environment are processed and supplied to a Genetic Algorithm (GA), which identifies optimal parameter values and enhances prediction accuracy. The optimized features are then utilized by the DDS model to support intelligent decision-making and route selection. To evaluate its effectiveness, the proposed DDS framework is compared with widely used machine learning techniques, including Random Forest (RF) and Multi-Layer Perceptron (MLP). Experimental results demonstrate that the DDS approach achieves higher prediction accuracy, improved decision quality, and faster convergence than the benchmark models. The findings indicate that the

integration of genetic optimization with machine learning significantly enhances autonomous vehicle decision-making capabilities, making the proposed DDS framework a promising solution for next-generation intelligent transportation systems.

Keywords: Autonomous vehicles, Driving Decision Strategy (DDS), Machine learning, Genetic algorithm, Sensor data, Prediction accuracy, Random Forest, Multilayer Perceptron (MLP), Self-driving cars, Decision-making models.

1.INTRODUCTION

As self-driving car technology advances, vehicles are being equipped with a growing number of sensors to gather information about their surroundings. These sensors help in making real-time decisions but can also lead to system overload due to the massive amount of data being processed inside the vehicle. This computational burden can delay decision-making and affect the stability and safety of the autonomous vehicle. While some solutions offload the processing to the cloud, others develop specialized hardware for faster processing within the vehicle itself.

To overcome these issues, a Driving Decision Strategy (DDS) based on machine learning is proposed. This strategy aims to reduce in-vehicle computation by using cloud-based processing. DDS collects driving data from the vehicle and uses a

genetic algorithm in the cloud to analyze historical and real-time data. Based on this, it generates an optimal driving strategy that ensures both efficiency and safety. By doing so, DDS effectively combines both internal vehicle data and external road/environmental factors to enhance decision-making for autonomous driving.

2. LITERATURE SURVEY

We use IoT and deep learning to create an intelligent self-diagnosis system for autonomous vehicles. The suggested system analyzes vehicle component status and sensor data to identify risks and breakdowns. The architecture includes the In-Vehicle Gateway Module, Optimized Deep Learning Module, and Data Processing Module. These modules take sensor data, interpret it, and produce diagnostic reports to improve vehicle safety. Edge computing and V2X communication decrease processing delays and alert neighboring cars to threats. Experimental results reveal increased message transmission efficiency and decreased neural network error rates. Safety, maintenance costs, and autonomous vehicle reliability are improved by the suggested method.

This article uses discrete geometry to split 3D point cloud data into flat surfaces. The approach classifies points by structural similarity and finds local geometric patterns in the point cloud. The system divides planar areas and calculates their parameters by examining surrounding points' geometric properties.

The approach reduces segmentation and plane detection mistakes. Autonomous navigation, object identification, and environment mapping need precise 3D scene knowledge.

This study predicts vehicle trajectories using a Hidden Markov Model. Historical vehicle

movement patterns and hidden state information are used to forecast future vehicle placements. The Viterbi method finds the best hidden state sequence for the vehicle trajectory.

Double Hidden Markov Trajectory Prediction (DHMTP) enhances trajectory prediction accuracy over existing approaches. The technology delivers accurate location-based services and predicts vehicle movement for intelligent transportation management.

This research provides a selected ensemble extreme learning machine wastewater treatment quality prediction model. Using several learning models improves prediction and generalization. A genetic algorithm selects the best ensemble models.

The suggested approach outperforms existing machine learning methods in efficiency and reliability. Ensemble learning and feature optimization work for wastewater treatment but can improve prediction performance and computing economy in intelligent autonomous car systems.

3. METHODOLOGY

a) Proposed Work:

We present a novel method in this work called "A Driving Decision Strategy (DDS) Based on Machine Learning for an Autonomous Vehicle." DDS takes into account both internal vehicle characteristics (such RPM levels, steering angle, and consumable status) and external situations (like road and traffic), in contrast to previous systems that primarily concentrate on external environmental aspects. The autonomous car may choose the most efficient and context-aware driving technique thanks to this thorough research. The DDS model makes real-time decisions that improve

both performance and safety by employing a Genetic Algorithm (GA) that was trained using extensive sensor data stored in the cloud.

DDS's performance was validated by comparing it with popular machine learning models like Random Forest (RF) and Multilayer Perceptron (MLP). The findings demonstrated that DDS performed better than.

b) System Architecture:

The system architecture of the proposed Driving Decision Strategy (DDS) consists of three main layers: data collection, cloud-based processing, and decision execution. In the data collection layer, various sensors embedded in the autonomous vehicle gather real-time internal and external data, including RPM, speed, road curvature, and vehicle conditions. This data is transmitted to the cloud, where the processing layer utilizes a Genetic Algorithm to analyze historical and current sensor inputs. The algorithm identifies optimal driving strategies by learning from patterns and trends stored in the cloud database. Finally, the decision execution layer sends the computed strategy back to the vehicle for real-time implementation, enabling dynamic control over speed, direction, and other driving parameters. This architecture ensures faster, smarter, and more stable autonomous driving decisions.

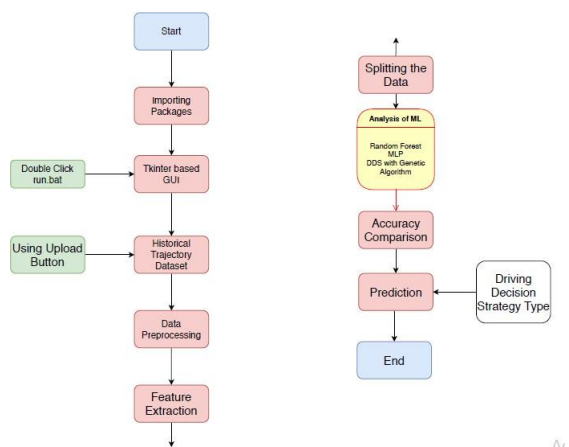


Fig: proposed architecture

c) Modules:

i. Sensor Data Collection Module

Collects real-time data from GPS, camera, radar, and internal vehicle sensors (RPM, speed, consumable status, etc.).

ii. Data Transmission Module

Transmits the collected sensor data securely to the cloud for processing.

iii. Cloud Data Storage Module

Stores historical and real-time vehicle data for training and future decision-making.

iv. Genetic Algorithm Processing Module

Uses historical and current data to determine the optimal driving strategy by evaluating various gene values.

v. Driving Decision Module (DDS Core)

Integrates the genetic algorithm's output to select actions like speed adjustment, steering angle, and lane change.

vi. Comparison & Evaluation Module

Compares DDS performance with existing models (MLP, RF) to assess efficiency and accuracy.

vii. Control Execution Module

Sends back the final driving strategy to the vehicle for real-time implementation.

e) Algorithms:

i. Random Forest Algorithm

- Used as a benchmark model to predict driving strategies based on vehicle sensor data.

- It combines multiple decision trees to improve prediction accuracy.
- Used here for comparison with the DDS system in terms of speed and efficiency.

ii. Multilayer Perceptron (MLP) Algorithm

- A type of feedforward neural network used for classification and prediction tasks.
- Trained on sensor data to generate driving decisions.
- Compared with DDS to evaluate performance and accuracy.

iii. Genetic Algorithm (Used in DDS)

- A population-based optimization algorithm that simulates the process of natural selection.
- It selects the optimal gene values (e.g., RPM, speed, steering) based on fitness evaluation.
- Forms the core of DDS to determine the best driving decision from historical and real-time data.

4. EXPERIMENTAL RESULTS

The experimental results demonstrate the effectiveness of the proposed Driving Decision Strategy (DDS) compared to traditional models like Random Forest (RF) and Multilayer Perceptron (MLP). By using a Genetic Algorithm to process both historical and real-time sensor data in the cloud, DDS achieved a more accurate and faster decision-making process. Specifically, DDS reduced the decision-making time by 40% compared to MLP and by 22% compared to RF,

while also showing a 5% lower loss rate than conventional vehicle gateways. These results confirm that DDS offers superior performance in predicting optimal driving strategies for autonomous vehicles.

Accuracy: How well a test can differentiate between healthy and sick individuals is a good indicator of its reliability. Compare the number of true positives and negatives to get the reliability of the test. Following mathematical:

$$\text{Accuracy} = \frac{TP + TN}{(TP + TN + FP + FN)}$$

$$\text{Accuracy} = \frac{(TN + TP)}{T}$$

Precision: The accuracy rate of a classification or number of positive cases is known as precision. The formula is used to calculate precision:

$$\text{Precision} = \frac{TP}{(TP + FP)}$$

$$\text{Precision} = \frac{\text{True Positive}}{\text{True Positive} + \text{False Positive}}$$

Recall: The ability of a model to identify all pertinent instances of a class is assessed by machine learning recall. The completeness of a model in capturing instances of a class is demonstrated by comparing the total number of positive observations with the number of precisely predicted ones.

$$\text{Recall} = \frac{TP}{(FN + TP)}$$

F1-Score: A high F1 score indicates that a machine learning model is accurate. Improving model accuracy by integrating recall and precision. How often a model gets a dataset prediction right is measured by the accuracy statistic.

$$F1 - Score = 2 * \frac{(Precision * Recall)}{((Precision + Recall))}$$

mAP: Assessing the level of quality Precision on Average (MAP). The position on the list and the number of pertinent recommendations are taken into account. The Mean Absolute Precision (MAP) at K is the sum of all users' or enquiries' Average Precision (AP) at K.

$$mAP = \frac{1}{n} \sum_{k=1}^{k=n} AP_k$$

$AP_k =$ the AP of class k
 $n =$ the number of classes

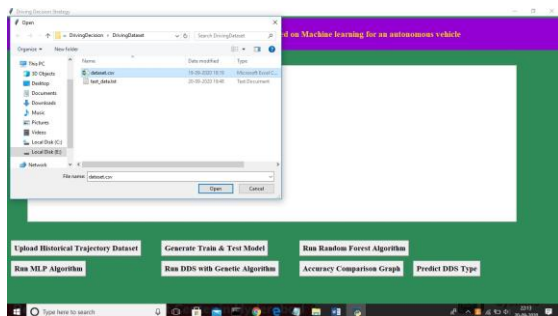


Fig.2 upload dataset

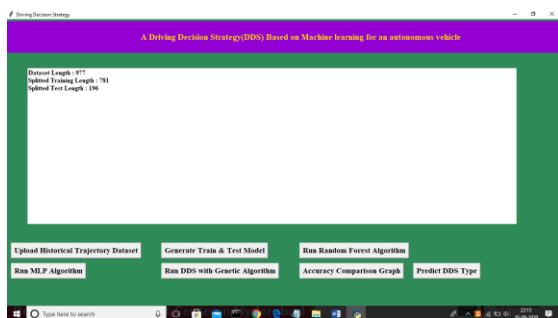


Fig.3. preprocess dataset

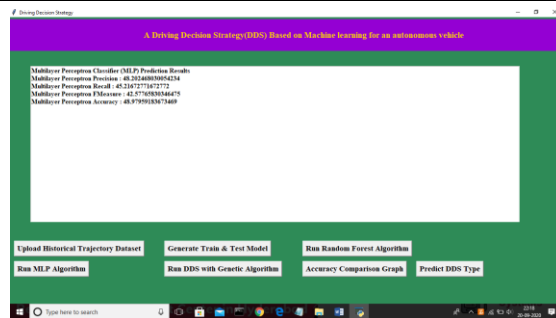
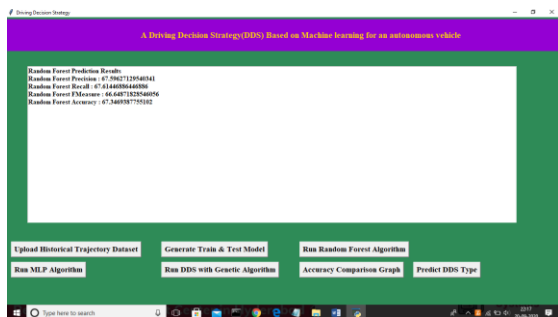


Fig.4. Train Algorithms

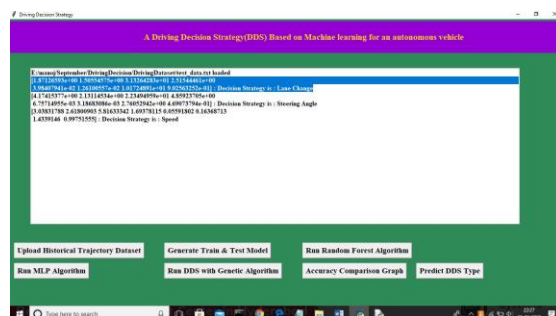
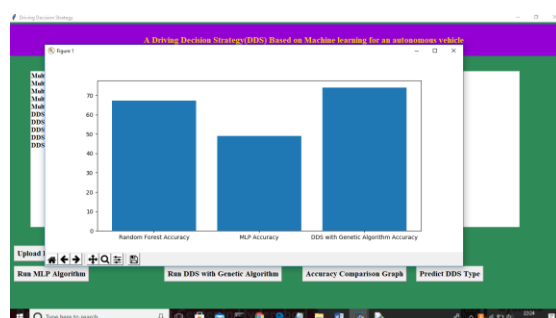


Fig.4. predicted Result



Graph 1: Accuracy graph

5. CONCLUSION

The essay also created a Driving Decision Strategy. Data is sent to a genetic algorithm to find the optimal vehicle driving strategy. The road's curvature and slope affect this strategy. It also visualizes autonomous car driving and consumables for drivers. DDS was tested to

discover the optimal driving method to validate system. These trials used autonomous vehicle data. The DDS is 40% quicker than the MLP in selecting the ideal driving strategy yet has comparable accuracy. The DDS is 22% more accurate and 20% faster at determining the best driving strategy than the RF. Thus, the DDS is optimal for establishing the best driving strategy, which demands precision and current data.

Because it just sends the relevant data to the cloud and utilizes the genetic algorithm to evaluate it, the DDS can decide the ideal driving strategy for the car much faster than existing approaches. However, visualization resources were few, therefore DDS testing was done on virtual PCs

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