CINEFORUM
ISSN: 0009-7039
Vol. 66. No. S8, 2026 (S8)

Multi_Level Feature Extraction and Classification for Lane Changing Behaviour Prediction & Pod-Based Evaluation

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ABSTRACT
Lane changing is one of the most important driving actions, as it has a direct impact on both road safety and traffic flow. Being able to anticipate a driver's intention to switch lanes in advance can greatly support advanced driver-assistance systems (ADAS) and autonomous vehicles. Early prediction allows these systems to respond in time, helping to reduce the likelihood of collisions and improve overall driving efficiency.This work introduces a framework based on multi-level feature extraction to improve the prediction of lane change behavior. The approach considers various aspects of driving, including vehicle movement, surrounding traffic conditions, and behavioral patterns of the driver. By combining information from different sources, the system aims to achieve a more reliable understanding of lane changing decisions.The feature extraction process is organized into multiple levels. At the basic level, features are derived from direct measurements such as vehicle speed, acceleration, and steering input. The intermediate level focuses on the driving environment, including nearby vehicles, lane structure, and road characteristics. At a higher level, the model takes into account behavioral indicators like past driving patterns and possible driver intent. This layered representation helps in capturing both simple and complex factors that influence lane changes.After extracting these features, several machine learning models are used to classify driving behavior. Techniques such as Support Vector Machines, Random Forest algorithms, and deep learning models are trained to recognize whether a vehicle will maintain its lane or initiate a lane change within a short period. The models are tested using real driving data to measure their performance under different traffic situations.

1.INTRODUCTION

Predicting lane changing behavior plays an essential role in modern intelligent transportation systems and advanced driver assistance technologies. The ability to recognize a driver's intention to change lanes at an early stage helps autonomous vehicles make safer and more informed decisions. This not only improves road safety but also contributes to smoother traffic flow and reduces the chances of accidents. As connected and automated vehicle technologies continue to expand, accurately modeling driver behavior has become a key research focus.Lane changing itself is a challenging driving action because it depends on several interconnected factors. These include the motion of the vehicle, the driver's intent, nearby traffic conditions, and the design of the road. Earlier approaches based on fixed rules or physical models often struggle to represent the unpredictable and complex nature of human driving. Due to these limitations, researchers have increasingly shifted toward data-driven methods, especially machine learning and deep learning techniques, which can better capture hidden patterns in driving data.In this context, multi-level feature extraction has proven to be a useful strategy for improving prediction performance. This approach gathers information from different layers of data. Basic features describe vehicle behavior, such as speed, acceleration, and position within the lane. More advanced features capture the surrounding environment, including traffic density and interactions with other vehicles, as well as possible driver intentions. Combining these different levels of information allows prediction models to gain a more complete understanding of driving situations, leading to more accurate and reliable results.

2.LITERATURE SURVEY

(2020) Deep Learning for Temporal Behavior Modeling
In 2020, Zhang and colleagues introduced a Temporal Convolutional Network (TCN) model for predicting lane change behavior. Their approach focused on learning patterns over time from sequential driving data. Compared to traditional Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs), the TCN model showed better performance in capturing long-term dependencies and achieved improved prediction results. The study highlighted that effective use of temporal information can enhance both accuracy and processing efficiency.In the same year, Shou et al. proposed a framework that combines Multilayer Perceptron (MLP) with RNN techniques for long-term lane change prediction. Using the NGSIM dataset, their model was able to predict lane change events several seconds in advance with reasonable accuracy. The research also emphasized the role of proper data labeling and smoothing methods in improving prediction consistency.
(2021) Machine Learning with Multi-Level Features
In 2021, Das and Ahmed explored a machine learning-based method using SHRP2 naturalistic driving data. Their

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work included features collected from different sources, such as vehicle motion parameters, road conditions, and driver-related factors. Multiple classification techniques, including Random Forest, Support Vector Machine (SVM), and XGBoost, were tested. The results indicated that ensemble learning methods tend to perform better in predicting lane change behavior.During the same period, Mozaffari et al. developed an attention-based Convolutional Neural Network (CNN) model capable of predicting both lane change intention and the time required to execute the maneuver. By incorporating attention mechanisms, the model was able to focus on important regions within the traffic environment, leading to improved feature representation and earlier detection of lane change actions.

3.EXISTING SYSTEM

Most existing systems for predicting lane changing behavior mainly depend on basic vehicle sensor information such as speed, acceleration, and steering input. These systems typically apply statistical methods or machine learning techniques to evaluate the current driving situation and estimate whether a lane change may occur. Although they provide useful predictions, they often do not consider deeper aspects such as driver intention or the broader traffic environment.A common limitation in many approaches is the use of features from only one level, usually focusing on vehicle motion or nearby traffic conditions. They rarely combine this information with behavioral indicators or past driving patterns. Because of this, such models may struggle to represent the complexity of real-world driving decisions, which can lead to reduced accuracy, especially in situations with heavy or unpredictable traffic.Some recent methods attempt to include driver-related information, such as eye movement or head position, to better understand intention. While this can improve prediction quality, it requires additional sensors and specialized equipment, making it difficult to apply in all types of vehicles. Moreover, these systems often treat different types of data separately instead of combining them into a unified framework, which limits their overall effectiveness.

Proposed System Description

The proposed approach is based on a multi-level feature extraction strategy that combines different types of information to improve lane change prediction. It brings together basic vehicle data, environmental conditions, and driver-related behavior into a single framework. By considering these multiple aspects at once, the system is able to develop a more complete understanding of the factors that influence a driver's decision to change lanes, resulting in better prediction performance.To identify lane change intentions, the system applies various machine learning methods such as Support Vector Machines, Random Forests, and deep learning models. These algorithms are trained using real-world driving datasets that include a wide range of traffic scenarios. This helps the model perform reliably under different conditions and improves its ability to generalize to new situations.Since handling a large number of features can increase complexity, the system uses Proper Orthogonal Decomposition (POD) to simplify the data. This technique helps in selecting the most important patterns from the dataset while removing less useful information. As a result, the model becomes more efficient and easier to interpret, while still maintaining strong prediction accuracy.

4.MODULE DESCRIPTION

The proposed system for lane changing behavior prediction is organized into several functional modules, each designed to perform a specific task in the overall workflow. These modules work together to ensure accurate prediction and reliable evaluation of lane change behavior.

A. Data Collection and Prepossessing Module

This module is responsible for gathering raw traffic and vehicle data from datasets or sensors. The collected data typically includes vehicle speed, acceleration, position, lane information, and surrounding vehicle details. Since raw data may contain noise, missing values, or inconsistencies, preprocessing steps such as data cleaning, normalization, and filtering are applied. The goal is to transform the raw input into a structured and usable format for further analysis.

B. Multi-Level Feature Extraction Module

In this module, relevant features are extracted from the processed data at different levels. Low-level features represent basic vehicle dynamics such as speed, acceleration, and relative distance. Mid-level features capture interactions with nearby vehicles, including gap distance and relative velocity. High-level features describe the driving context, such as traffic density, lane conditions, and possible driver intent. By combining features from multiple levels, the system gains a comprehensive understanding of the driving environment.

C. Feature Selection and Optimization Module

Not all extracted features contribute equally to prediction accuracy. This module selects the most relevant features while removing redundant or less significant ones. Techniques such as correlation analysis or recursive elimination can be used to improve efficiency. Reducing feature dimensional helps in minimizing computational complexity and enhances model performance.

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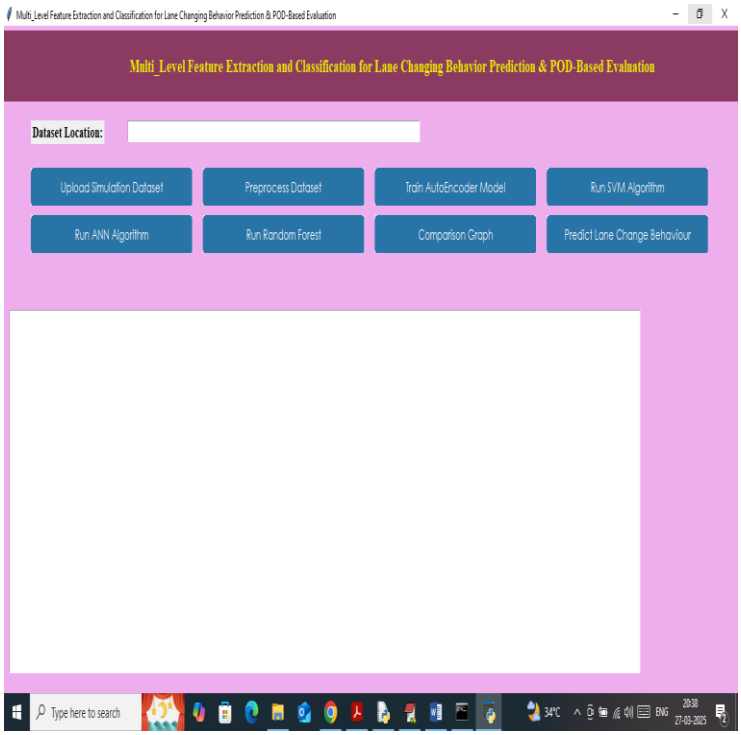
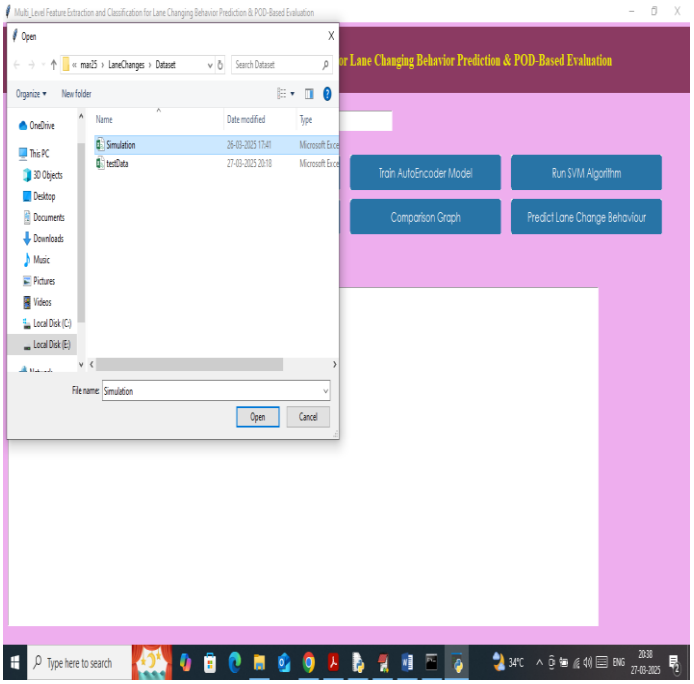
D. Classification Module
The classification module is responsible for predicting lane changing behavior based on the selected features. The model categorizes vehicle actions into classes such as left lane change, right lane change, or lane keeping. Machine learning algorithms such as Support Vector Machine (SVM), Random Forest, or neural networks can be employed. The classifier is trained using labeled data and then tested to evaluate its prediction capability.

5.RESULTS
To run project double click on 'run.bat' file to get below page



In above screen click on 'Upload Simulation Dataset' button to upload dataset and then will get below page



In above screen selecting and uploading simulation dataset and then click on "open" button to load dataset and then will get below page

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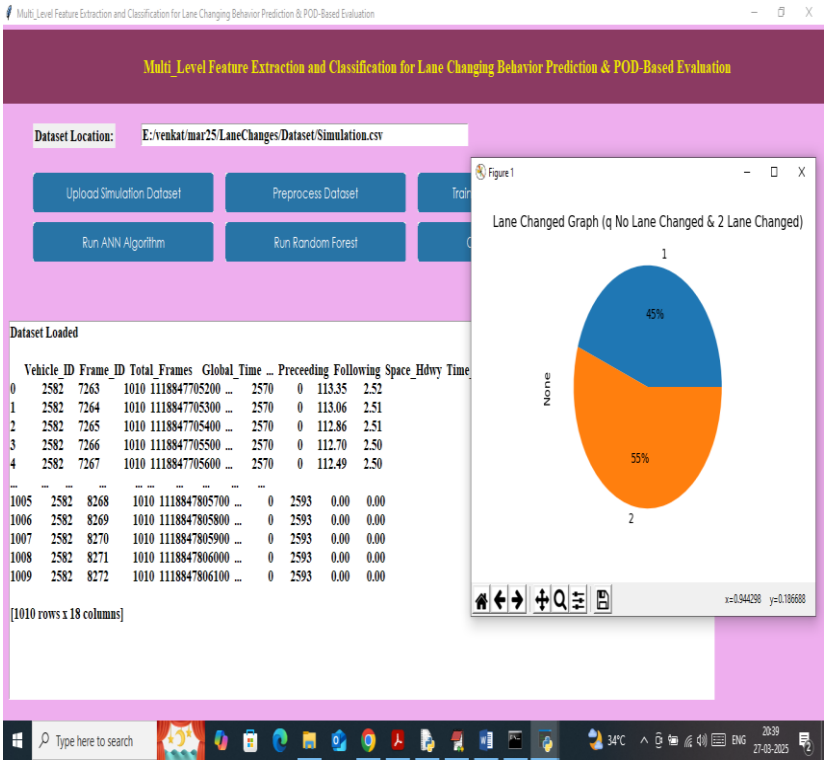
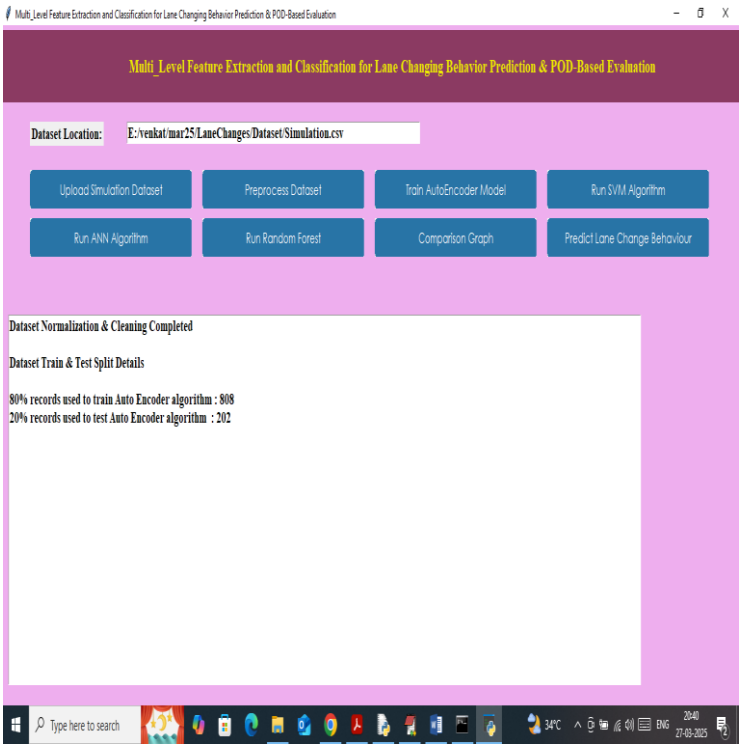


In above screen in text area can see some dataset values and then in graph can see percentage of lane changing and not lane changing behaviour. Now click on 'Pre-process dataset' button to clean and split dataset into train and test and then will get below page



In above screen dataset cleaning completed and then can see train and test size and now click on 'Train AutoEncoder Model' button to train model and then this model can be used to extract multi-level features

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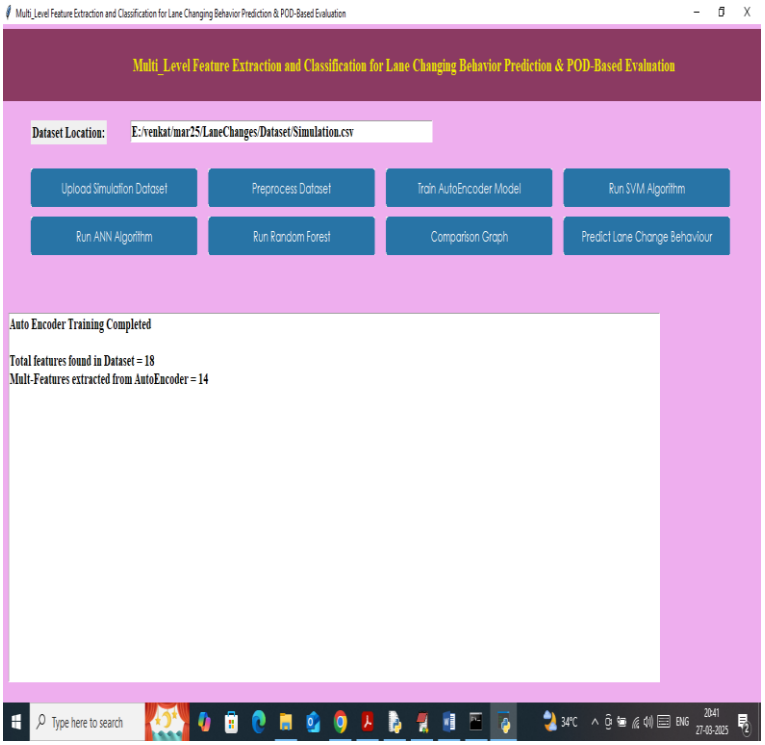

In above screen autoencoders training completed which get trained on 18 features and then extract 14 multi-level features and now click on 'Run SVM Algorithm' button to train on extracted features and then will get below page



In above screen SVM got 93% accuracy and its FAR as 0.061 and now click on 'Run ANN Algorithm' button to get below page

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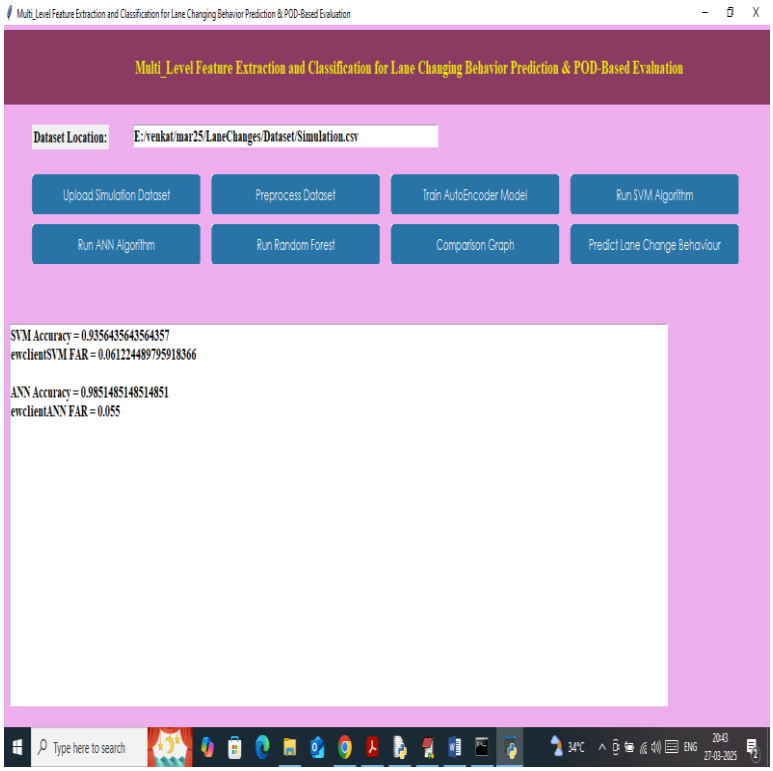
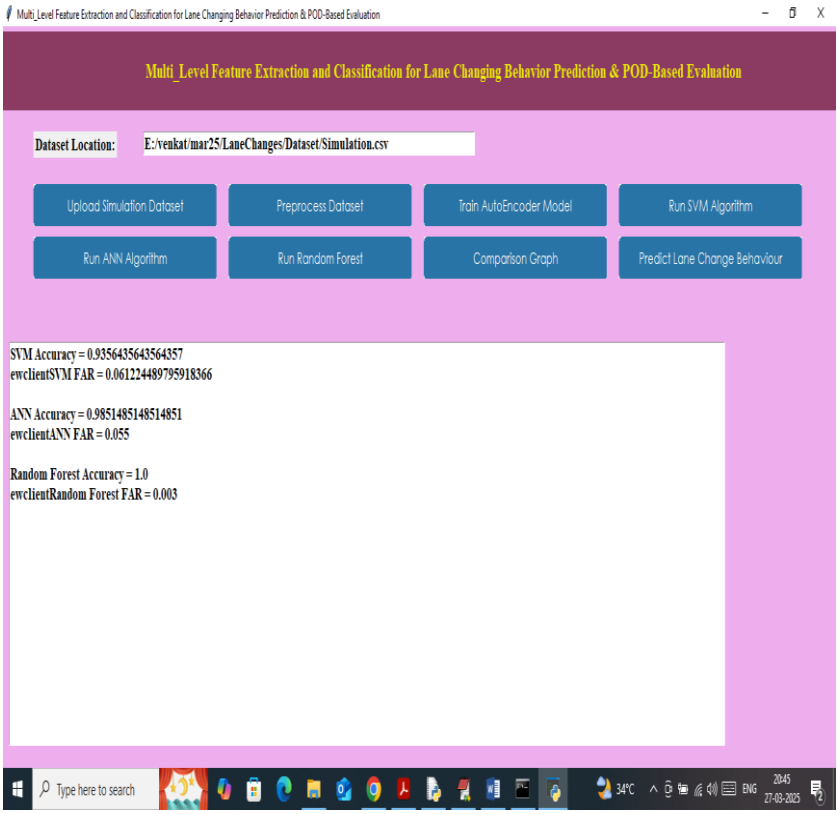


In above screen ANN got 98% accuracy and can see FAR as 0.055 and now click on 'Run Random Forest' button to train Random Forest and get below page



In above screen Random Forest accuracy is 100% and can see FAR as 0.003 and now click on 'Comparison Graph' button to get below page

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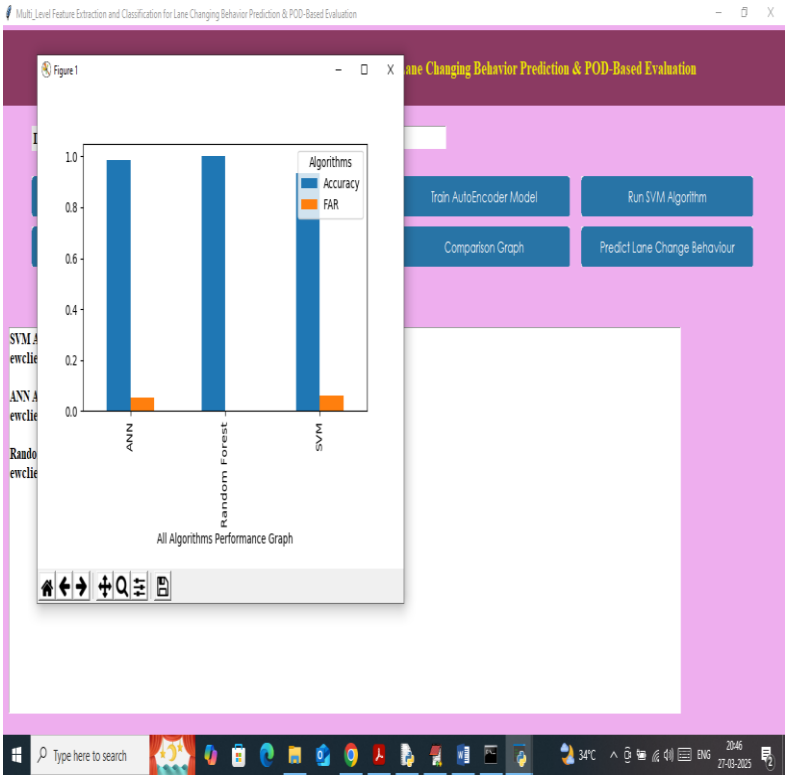
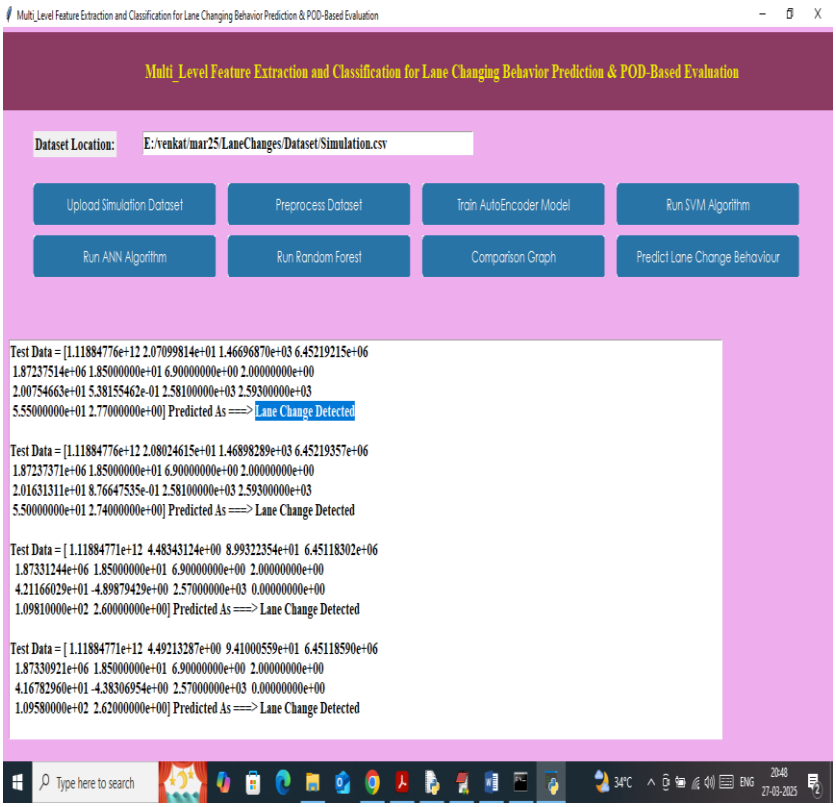


In above graph x-axis represents algorithm names and y-axis represents accuracy and FAR in different colour bars. In above graph can see Random Forest and ANN got high accuracy and less FAR. Now click on 'Predict Lane Change Behaviour' button to upload test data and get below output



In above screen in square bracket can see Test data values and then after arrow symbol can see predicted label as 'Lane Change Detected'. Scroll down above screen to view other prediction

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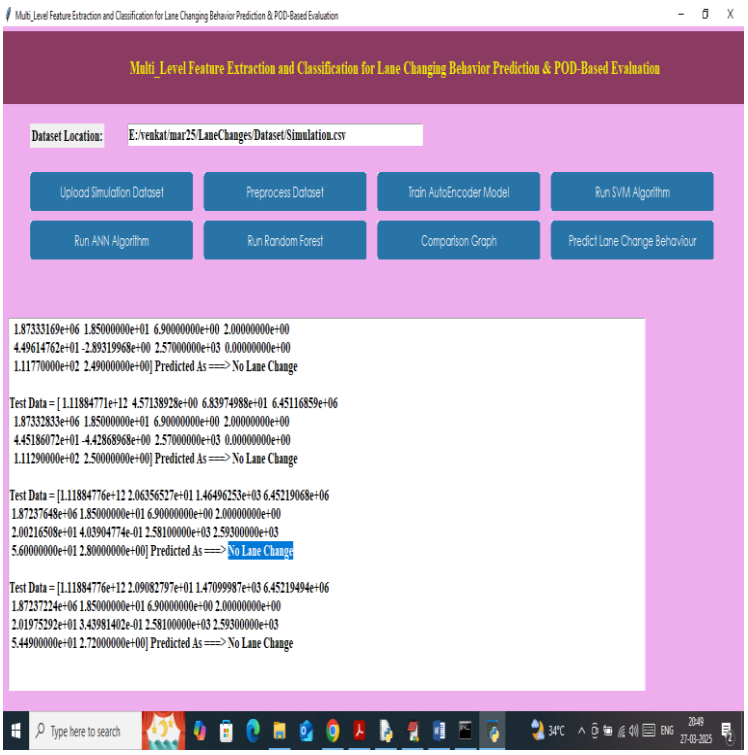

In above screen can see 'No Lane Change' detected.Similarly by following above screens you can run complete project

6.CONCLUSION

This work presented a structured approach for predicting lane changing behavior using a combination of multi-level feature extraction and classification techniques. By considering information at different levels, including vehicle motion, interaction with nearby vehicles, and overall traffic context, the system is able to capture the complexity of real driving situations more effectively than methods relying on limited inputs.The classification model plays a key role in identifying driving intentions such as lane keeping and lane changing. With properly selected features, the model can produce consistent and reliable predictions. In addition, the use of a Probability of Detection (POD)-based evaluation provides a clear understanding of how well the system identifies actual lane change events, which is important for safety-related applications.The results indicate that combining multiple feature levels improves prediction capability and reduces the chances of incorrect decisions. The modular structure of the system also makes it flexible, allowing improvements or replacements in individual components without affecting the entire framework..

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