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Title **DRIVING DECISION STRATEGY FOR AN AUTONOMOUS VEHICLE BASED ON MACHINE LEARNING**

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Paper Authors

Mr. Kishore Babu .S, Gayathri .M, Ananya .G, Likitha .K

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Driving Decision Strategy for an Autonomous Vehicle Based on Machine Learning

Mr. Kishore Babu .S[1], HoD, Department of Information Technology, Andhra Loyola Institute of Engineering and Technology, Vijayawada
Gayathri .M[2], Department of Information Technology, Andhra Loyola Institute of Engineering and Technology, Vijayawada
Ananya .G[3], Department of Information Technology, Andhra Loyola Institute of Engineering and Technology, Vijayawada
Likitha .K[4], Department of Information Technology, Andhra Loyola Institute of Engineering and Technology, Vijayawada

Abstract
An approach to driving decisions (DDS) A concept for driving decision-making for an autonomous car is based on machine learning, and it uses internal vehicle data, like steering and RPM level, to forecast different types of behaviour, like speed (steering), changing lanes, etc. All methods at the time were designed to focus on exterior data, such as the state of the roads and the number of people, but not on internal variables. So, the author is analysing internal data to determine the steering state and lane changes effectively. All internal data will be gathered from sensors, saved on the cloud, read by the application, and then subjected to ML algorithms to ascertain steering angle or changing lanes.
The DDS algorithm is based on a genetic algorithm to select the ideal gene values that aid in making better decisions or predictions, and is used to implement this. The genetic algorithm was used by the DDS algorithm to select the ideal value, enabling quicker and more accurate prediction.
Performance of the proposed DDS with genetic algorithm is compared to that of currently used machine learning techniques like Random Forest and MLP (multilayer perceptron algorithm.). Compared to random forest and MLP, the proposed DDS displays higher prediction accuracy.

Keywords: RF, MLP, DDS, genetic algorithm

1. Introduction

Autonomous vehicles are self-driving cars that use advanced technologies like sensors, cameras, and machine learning algorithms to sense their environment and make decisions about how to operate in it. They use various algorithms and software to perceive the surroundings, identify obstacles, and safely navigate the vehicle to the intended destination. In addition to driving themselves, autonomous vehicles can also communicate with other vehicles and transportation infrastructure, such as traffic lights and road signs, to optimise traffic flow and enhance safety. The development of autonomous vehicles is a rapidly advancing field in computer science and engineering, with the potential to revolutionise transportation and mobility for people and goods.

Autonomous driving systems are necessary for several reasons. Firstly, they can improve transportation safety by reducing the number of accidents caused by human error, which is a leading cause of road accidents. Autonomous vehicles can make more informed and accurate decisions than human drivers, as they can process and analyse vast amounts of data in real-time, such as road conditions, weather, and traffic patterns, to determine the best driving strategy.

Secondly, autonomous vehicles can improve transportation efficiency by reducing congestion, minimising travel time, and maximising fuel efficiency. They can communicate with each other and with transportation infrastructure, such as traffic lights, to coordinate their movements and avoid unnecessary delays.

Thirdly, autonomous driving systems can improve accessibility for people who cannot drive, such as the elderly or people with disabilities, by providing them with safe and reliable transportation.

Finally, autonomous driving systems can revolutionise the way we think about transportation, enabling new business models and services, such as ride-sharing and on-demand delivery, that were previously not possible. Overall, autonomous driving systems have the potential to enhance transportation safety, efficiency, accessibility, and convenience, making them a critical technology for the future of mobility.

2.1 Objective

The objective of building a Driving Decision Strategy for an Autonomous Vehicle is to develop a system that can determine the optimal driving strategy for the vehicle in real-time, based on various environmental factors such as road conditions, traffic patterns, weather, and vehicle performance data. The system should be able to make decisions quickly and accurately, ensuring the safety and comfort of passengers while maximising the vehicle's efficiency and performance. Additionally, the system should be scalable, adaptable, and able to learn from past experiences to improve its decision-making capabilities over time. Ultimately, the goal is to create a reliable, efficient, and intelligent autonomous driving system that can enhance transportation safety and revolutionise the way we travel.

2.2 Project Features

It executes the genetic algorithm based on accumulated data to determine the vehicle's optimal driving strategy according to the slope and curvature of the road in which the vehicle is driving and visualises the driving and consumables conditions of an autonomous vehicle to provide drivers. To verify the validity of the DDS, experiments were conducted on Desoto to select an optimal driving strategy by analysing data from an autonomous vehicle. Though the DDS has a similar accuracy to the

MLP, it determines the optimal driving strategy 40% faster than it. And the DDS has a higher accuracy of 22% thanRF and determines the optimal driving strategy 20% faster than it.

3. Literature Survey

Reference No.	Title	Authors
[1]	"An Integrated Self-Diagnosis System for an Autonomous Vehicle Based on an IoT Gateway and Deep Learning, " Applied Sciences, vol. 8, no. 7, july 2018	Y.N. Jeong, S.R.Son, E.H. Jeong and B.K. Lee
[2]	"Discrete Plane segmentation and estimation from a point cloud using local geometric patterns, " International Journal of Automation and Computing, Vol. 5, No. 3, pp.246-256, 2008.	Yukiko Kenmochi, Lilian Buzer, Akihiro Sugimoto, Ikuko Shimizu
[3]	"Vehicle trajectory prediction based on Hidden Markov Model, " The KSII Transactions on Internet and Information Systems, Vol. 10, No. 7, 2017.	Ning Ye, Yingya Zhang, Ruchuan Wang, Reza Malekian
[4]	"Selective ensemble extreme learning machine modelling of effluent quality in wastewater treatment plants, " International Journal of Automation and Computing, Vol.9, No.6, 2012	Li-Jie Zhao, Tian-You Chai, De-Cheng Yuan
[5]	Hybrid neural network modelling of Bioengineering, vol. 78, no. 6, pp. 670–682, 2002.	D. S. Lee, C. O. Jeon, J. M. Park, K. S. Chang
[6]	Use of artificial neural network black-box modelling for the prediction of wastewater treatment plants performance.	Mjalli FS, Al-Asheh S, Alfadala HE.J

4. Existing System & Limitations

Existing system used k Nearest Neighbour, RF, Bayes and SVM models. kNN can be expensive in terms of computations , especially with larger datasets, since it needs to calculate euclidean distances between the test sample and all training samples. SVM is sensitive to the choice of kernel function and parameters, which can affect its performance. Bayes assumes independence between features, which may not always be the case in real-world scenarios.

All three algorithms may not perform well with high-dimensional data or imbalanced datasets, where one class may be significantly more prevalent than another.

These algorithms require labelled training data to learn from, which can be difficult and time-consuming to obtain in certain domains.

The performance of these algorithms may also depend on the quality and representativeness of the training data used, which can be a challenge in real-world scenarios where data can be noisy, incomplete, or biassed.

Limitation:

lower effectiveness and need further are to explored for forestallment

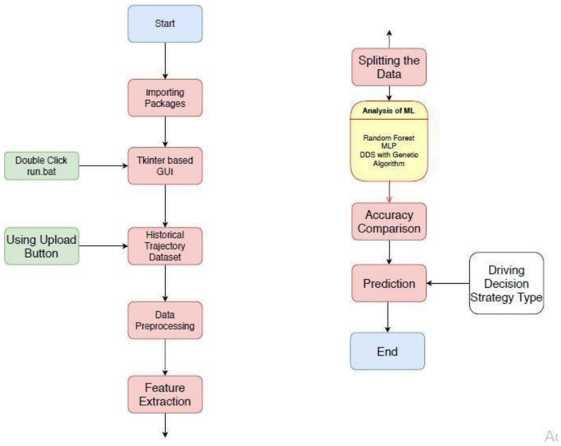
5. Proposed System & Advantages Then we propose “Decision Strategy for Driving of an Autonomous Vehicle(DDS) based on Machine literacy”, which determines the ideal strategy of an self-driving vehicle by analysing the external factors and the internal factors of the vehicle (The conditions in which consumables are used and the situations in which RPM [revolutions per minute] occurs.). The DDS is based on a genetic algorithm and uses sensor data from vehicles stored in the cloud storage and determines the ideal driving strategy of a self-driving vehicle. We are about to contrast the DDS with MLP, RF neural network models to validate the DDS.

Advantages:

These advancements system to control the vehicle grounded on detector data rather than external data.

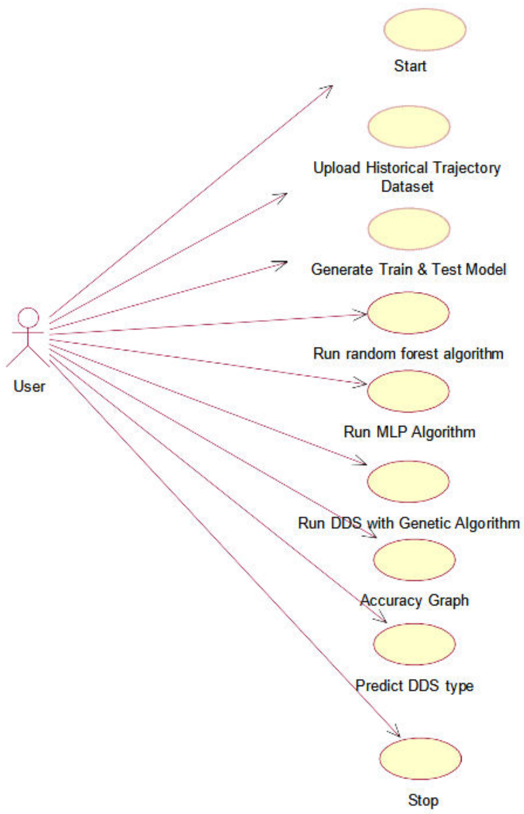
6. System Design

6.1 Architecture



6.2 Use-Case Diagram

Graphical summary of the practicality handed by a system in terms of actors, their pretensions(represented as use cases), and any dependencies between those use cases. The main purpose of a use case illustration is to indicate what system functions are performed by that actor. places of the actors within the system are represented.



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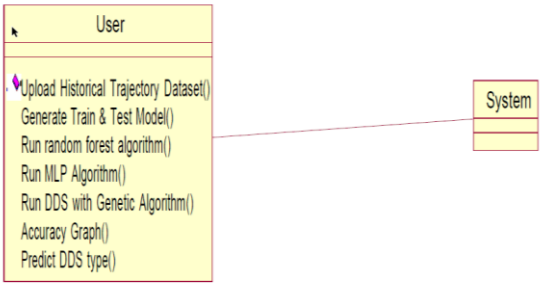
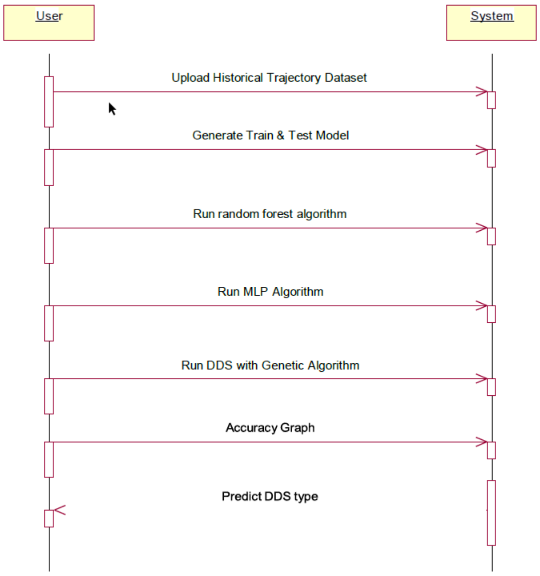
6.3 Class Diagram

Class Diagrams depicts the classes, methods and objects that are to be developed in a system..



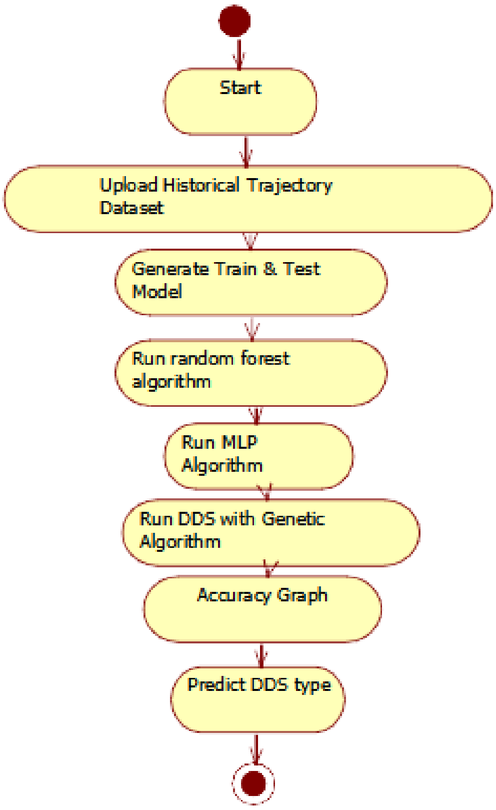
6.4 Sequence Diagram

Sequence Diagrams depict the order of interactions between different components in a system.



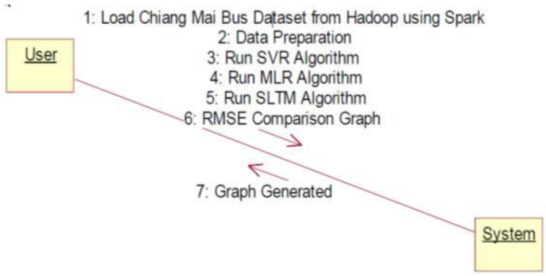
***6.5* State Diagram**

State diagram explains the various states or situations that an object can be in.



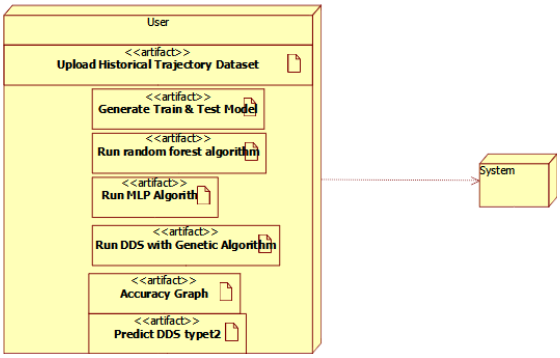
6.6 Communication Diagram

A Communication diagram is a diagram that depicts how objects and actors in a system interact with each other.



6.7 Interaction Overview Diagram

An interaction overview diagram is a UML diagram that shows interactions between objects or parts of a system. It's used to visualise complex interactions and workflows between multiple components in a system. The diagram shows the steps of the interaction as well as the participants involved, making it easier to understand the overall flow of the system.



7. Modules

7.1 Upload Historical Trajectory Dataset: Collected required sensor data from kaggle.

7.2 Create a model for training and testing: Preprocess the gathered data, split into two parts: training and testing, 80% and 20% respectively.

7.3 Execute RF Classifier: We have to train the RF with train data and test the RF with test data to get the best result from the algorithm.

7.4 Execute the MLP algorithm. Instruct the MLP with training data and test the model with testing data.

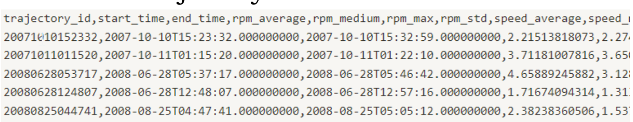
7.5 Execute the DDS algorithm. We have to train the DDS with Genetic Algorithm with train data and test the DDS with Genetic Algorithm with test data to get the best result from the algorithm.

7.6 Accuracy Comparison Graph: We will find the best algorithm with highest accuracy in the form of graph.

7.7 Predict DDS Type: Enter the test data to predict the direction of a car using the DDS with Genetic Algorithm.

8. Dataset

Historical Trajectory Dataset



```
trajectory_id,start_time,end_time,rpm_average,rpm_medium,rpm_max,rpm_std,speed_average,speed_
20071010152332,2007-10-10T15:23:32.000000000,2007-10-10T15:32:59.000000000,2.21513818073,2.27
20071011011520,2007-10-11T01:15:20.000000000,2007-10-11T01:22:10.000000000,3.71181007816,3.65
20080628053717,2008-06-28T05:37:17.000000000,2008-06-28T05:46:42.000000000,4.65889245882,3.12
20080628124807,2008-06-28T12:48:07.000000000,2008-06-28T12:57:16.000000000,1.71674094314,1.31
20080825044741,2008-08-25T04:47:41.000000000,2008-08-25T05:05:12.000000000,2.38238360506,1.53
```

'Sample data'

Description:

This is a block of data, containing information about different trajectories. For each trajectory, it shows the trajectory ID, start and end times, average, medium, maximum and standard deviation of the engine RPM (Revolutions Per Minute) and speed, as well as the label of the trajectory (whether it is a normal speed, steering angle or lane change).

9Algorithms

Random Forest Algorithm

Random Forest is a classifier consisting of numerous decision trees and data is fed to each and every tree and the average of output of every tree is the improvised solution.

Assumptions for RF

There should exist some values for the feature variables of the data set for accurate prediction and the predictions should not have any correlations.

Working of RF

There are two phases in RF working

1. Create a forest by combining N decision trees
2. Make predictions for each tree

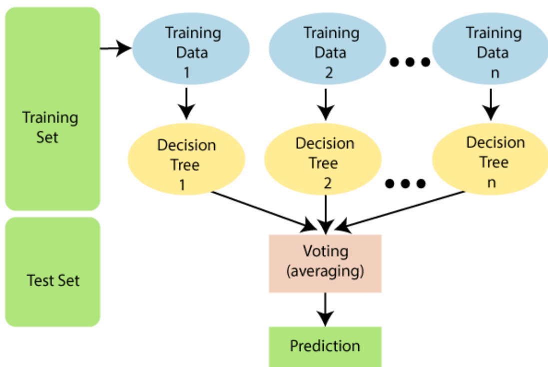
1: Select K no. of records from the data set

2: Construct trees based on the selected K records

3: Select N for building trees

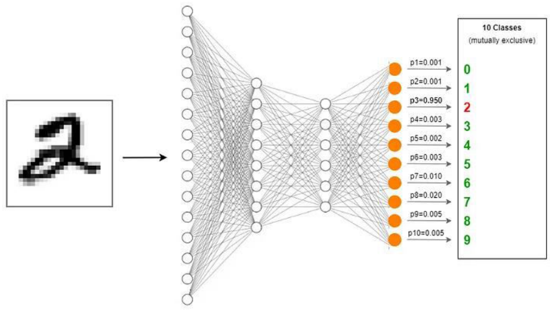
4: Iterate through 1 and 2

5: For new records, generate predictions for each tree, and map the new records to the class with the most predictions wins.



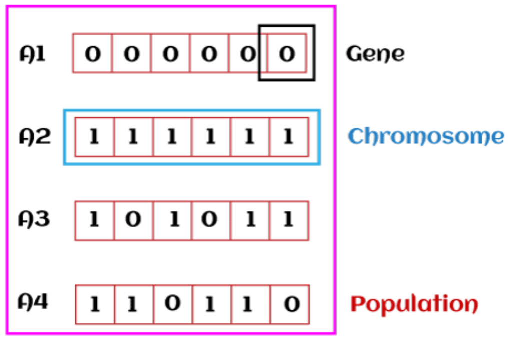
9.2 MLP

Multi-layer perceptron has one input subcaste(input subcaste can have multiple bumps or neurons), one affair subcaste with a single knot for each affair and multiple retired layers and each retired subcaste can have any number of bumps. The bumps in the input subcaste take input and further it for further process, the retired subcaste processes the information and passes it to the affair subcaste. Every knot in the MLP uses a sigmoid function which takes real values and converts them to figures between 0 and 1. In order to make an MLP in python Tensor inflow is used.



9.3 Genetic Algorithm Terminology

Population: subset of all possible results
Chromosome: A result in population Gene
Allele: Literal assigned to an element
Fitness Function: Evaluates quality of a solution in an Optimisation problem.



A genetic algorithm is a type of optimization algorithm inspired by the process of natural selection and genetics. It is a type of evolutionary algorithm that uses principles such as selection, crossover, and mutation to generate new candidate solutions to a problem. Genetic algorithms are often used in optimization problems where traditional methods are not feasible or do not provide satisfactory results.

- Heuristic search is an AI approach that tries to find a good solution among the available choices, even if it is not the perfect one. It does this by ranking the available options at each step of the search and selecting the most promising one. Unlike other search methods, heuristic search doesn't focus on finding the optimal solution, but rather aims to find a reasonable one quickly within a given time limit or memory space.

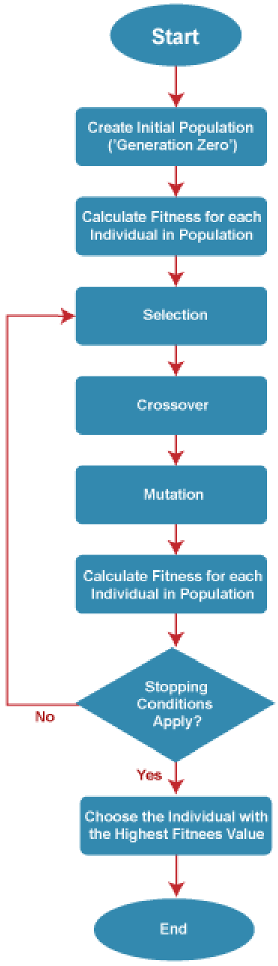
It principally involves five phases to break the complex optimization problems, which are given as below

- Initialization The process of generating all possible results(population), each result is called as an existent. Every result(existent) is characterised by a set of parameters(genes). Each parameter(gene) is concatenated as a string to induce chromosomes.

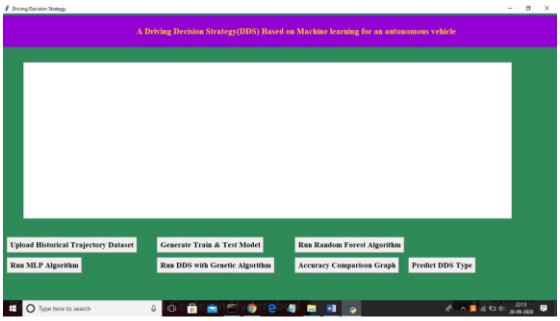
- Fitness Assignment Determines score for each result so that it can be used in the reduplication phase. The result with advanced score is used for reduplication.
1
- Selection Involves selection of individualities for reduplication. All named individualities or chromosomes are paired for reduplication. There are three types of selections

- Reproduction: The process of generating a seed from the named individualities. Simply creating an extemporised result using two named results.

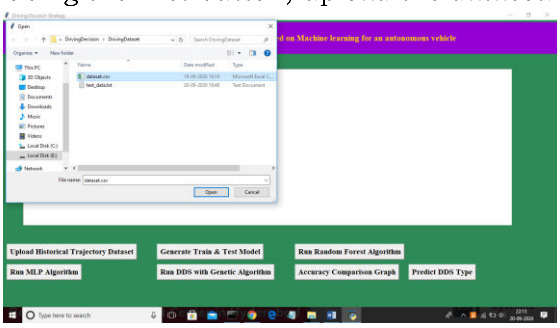
- Termination: The stopping criterion used for the algorithm to stop since it's an iterative process.



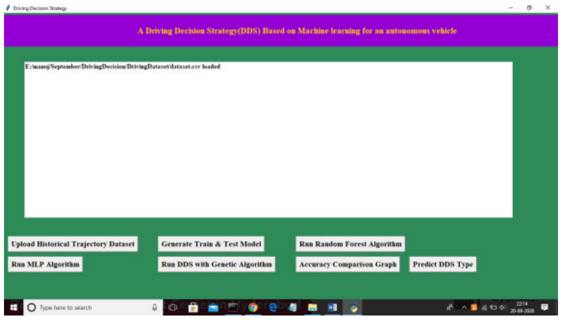
10. RESULT



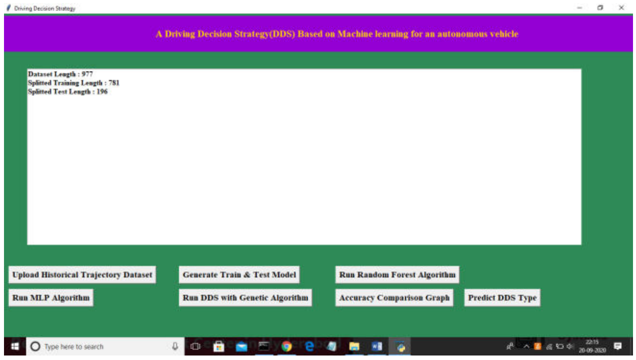
Using the first button, upload the dataset.



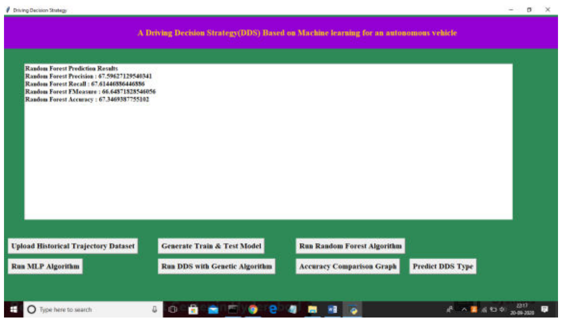
It opens up the explorer. select the dataset file and open it to load and to get the screen below.



After uploading the dataset, click on the second button to skim through the dataset, divide the whole points in to two (train and test) and build an ML Model



The window now displays 977 total trajectory records in the dataset file 781 (80% of dataset) records are for training and 196 (20% of dataset) are for testing. Click on the third button to train an RF Classifier and test it with the 20% test data.



RF model accuracy is about 67% and even displays accuracy, precision, f-measure and even recall of it. Now click the 4th button to build the MLP Model.

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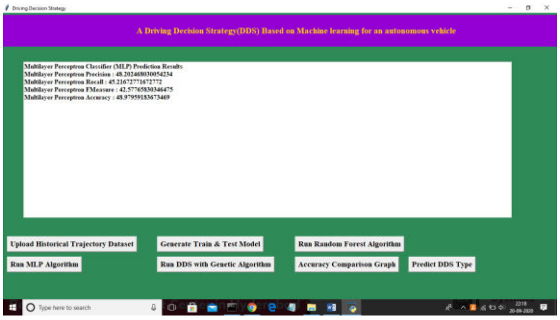
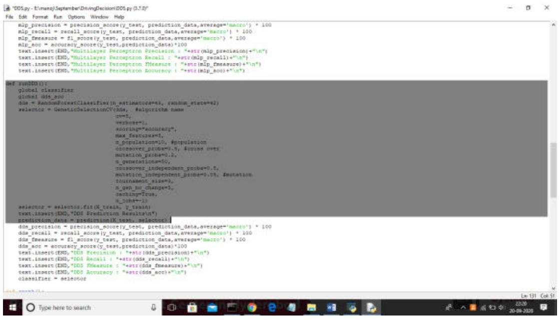
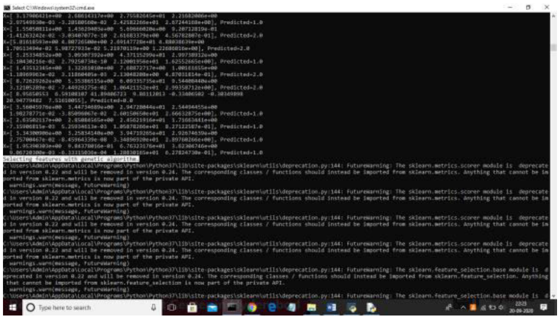


MLP accuracy is about 48%. Now click on Genetic button to run the next algorithm.

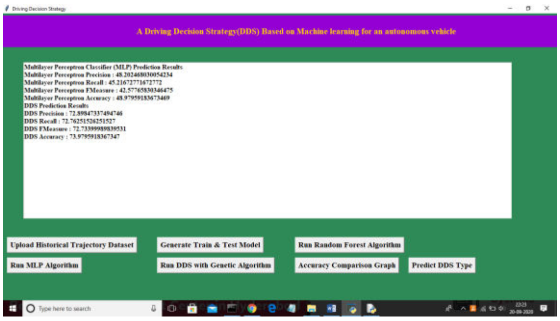


Window displaying code used in genetic algorithms.

Click on the 6th button to run DDS.

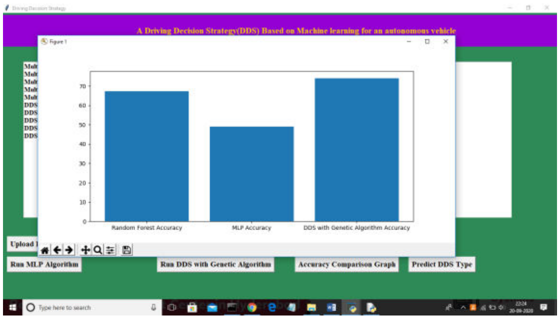


The black console is using a genetic algorithm to select the best features.



DDS accuracy is about 73%.

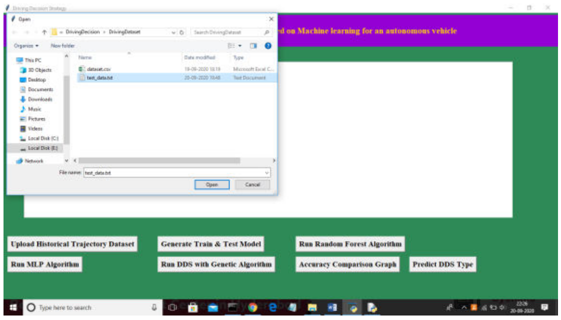
Now compare accuracies using the button provided in the GUI.



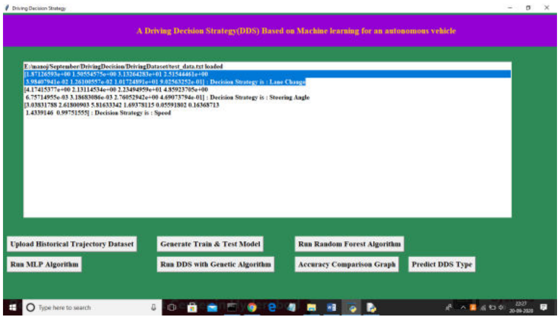
X-axis Algorithm

Y-axis Accuracy

The graph concludes that DDS performs better than the other algorithms.



Upload the test dataset file.



In the window, there are three examples shown. The first example is about a car changing lanes, the second example is about the car turning its wheels, and the third example is about the car moving at a certain speed. A computer program is predicting what the car is doing based on some information it has, and it shows the predicted value for each example.

11. Conclusion

The proposal is about a new method called DDS for determining the best driving strategy for autonomous vehicles based on the road's pitch and curve. DDS uses an inheritable algorithm that analyses data from an independent vehicle to find the optimal driving strategy faster and more accurately than other methods. DDS is 40 times faster than MLP and 20 times faster than

RF. It only sends crucial data to the computer, which analyses it and determines the best driving strategy quickly. However, the DDS has only been tested virtually, and more resources are needed for visualisation.

12. Future Scope

To test if the DDS works well in real-life situations, researchers should use it on real vehicles. They should also improve the visual design of the system with the help of professional designers.

13.References

[1] Y.N. Jeong, S.R.Son, E.H. Jeong and B.K. Lee, “An Integrated Self- Diagnosis System for an Autonomous Vehicle Based on an IoT Gateway and Deep Learning, ” Applied Sciences, vol. 8, no. 7, july 2018.

[2] Yukiko Kenmochi, Lilian Buzer, Akihiro Sugimoto, Ikuko Shimizu, “Discrete plane segmentation and estimation from a point cloud using local geometric patterns, ” International Journal of Automation and Computing, Vol. 5, No. 3, pp.246-256.

[3] Ning Ye, Yingya Zhang, Ruchuan Wang, Reza Malekian, “Vehicle trajectory prediction based on Hidden Markov Model, ” The KSII Transactions on Internet and Information Systems, Vol. 10, No. 7, 2017.

[4] Li-Jie Zhao, Tian-You Chai, De-Cheng Yuan, “Selective ensemble extreme learning machine modelling of effluent quality in wastewater treatment plants, ” International Journal of Automation and Computing, Vol.9, No.6, 2012