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MACHINE LEARNING BASED AUTOMATED DRIVER - BEHAVIOR PREDICTION FOR AUTOMOTIVE CONTROL SYSTEMS

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Abstract

The impact of good driving and rode safety plays a major role in automobile sector. Though autonomous driving and modern driving techniques are improving worldwide, the study of driver behavior and characteristics become indispensable. The research on driving science has taken long strides since its inception. Driving behavior analysis requires more valid attributes and the evaluation process requires better prediction models .The role of Artificial intelligence and machine learning in driver-behavior prediction have given new dimension to extract valuable results. This paper deploys a novel scheme to predict the driver behavior using advanced machine learning technique.

Keywords: Driver behavior, Drowsiness detection, Machine learning, Traffic accident analysis

I. Introduction

The modern vehicular technologies have provided numerous modern tools in terms of driving facilities and entertainment. But the role of driver remains critical in any road transport communication. In this fast-paced world, the distraction and disturbances to the driver during the movement of vehicle can cause extreme problems and it may lead to fatal accidents. Diver monitoring is a broad area that needs better exploration. Driver-vehicle interaction factors such as the level of automation, transition control from the vehicle to human intervention, physiology and psychological factors of the driver should be analyzed carefully.

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The analysis about the driver characteristics can be performed in driving simulators or using real vehicles. Driving simulators offer good evaluation of the performance of drivers under controlled conditions. Using similar vehicle and traffic conditions, different subjects can be tested in a simulated environment. Also the inference can be assessed based on factors such as conditions on operator cognitive load, concentration and tiredness of the driver. The impact of eye tracking, facial expression and physiological sensing can be observed using the simulation tools. Advanced sensors can be used in real vehicles to investigate the overall impact of driver characteristics. This natural way of exploration gives more prominent results to further improvise the automated vehicle management system.

The accidents happening on road are due to variety of reasons. The association between the human factor (driver) and the automobile (machine) is a major feature in accident analysis. Also, the response of the driver towards difficult driving conditions such as weather disturbance and heavy traffic condition is worth mentioning[IV].

Road safety is an area of concern for most of the countries in the world. The road fatalities per 100,000 population according to the annual report (2013) of International Road Traffic and Accident Database (IRTAD) is shown in Fig.1.Most of the countries are showing below-par performance in addressing safety measures due to economic and infrastructure inadequacy [XI].

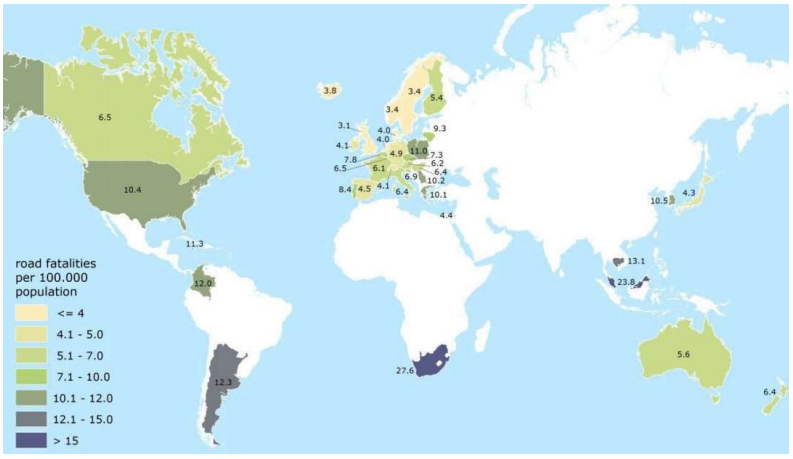

Fig.1: Accident data in 2011 - International Road Traffic and AccidentDatabase - report 2013.

In India, road traffic injuries are causing heavy loss to mankind. Different countries have different rules and regulations and the safety measures directly proportionate to the income level of the country. Road accidents are more severe in low-income countries. In economically weak countries, average rate of 27.5 deaths per 100,000 populations due to road traffic death is giving alarming signals. This rate is more than

three times than the mortality rate in high-income countries. According to global status report on road safety 2018 by World health organization, the rates of road traffic death are highest in places like Africa and South-East Asia.Keybehavioral risk factors such as speed, drink-driving and emotional/physical disturbances are contributing to this issue [IX]. Rates of road traffic death analysis with respect to Global status report on road safety2018 (world health organization) is elucidated in Fig.2.

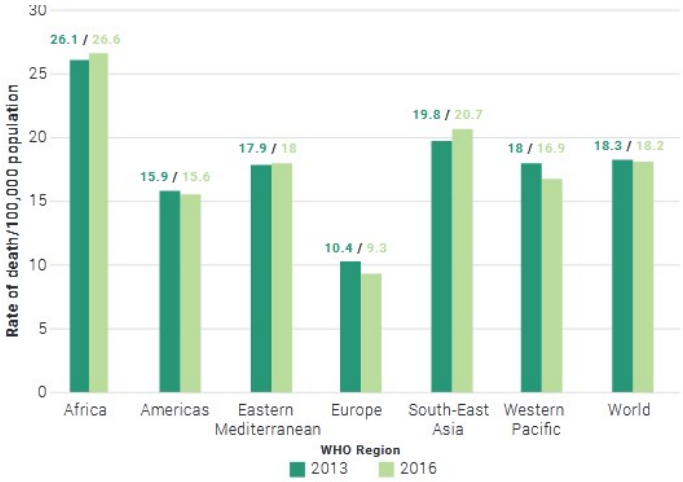

Fig.2: Rates of road traffic death per 100,000 population by WHO regions: 2013, 2016 [IX]

Driving Styles and Driver Behavior Factors

Driver behavior depends on the style within which the driver operates his/her vehicle. The driving styles can be classified as normal mode (safe travel mode), violent driving style, careless driving style and intoxicated driving style. Any style that deviates from the safe driving mode needs to be analyzed to infer productive results. A new model of driving style classification is done by[I]. The classification rating starting from normal mode to very hard driving characteristics is taken in to account. Irregular speed, improper vehicle position and uneven acceleration are the factors grouped under aggressive driving. Driver fatique and driver distraction are the reasons for inattentive driving[VIII].

Overall framework of the in-vehicle data recorder (IVDR) system is proposed by [XXV] and the model of the system is depicted in Fig. 3.

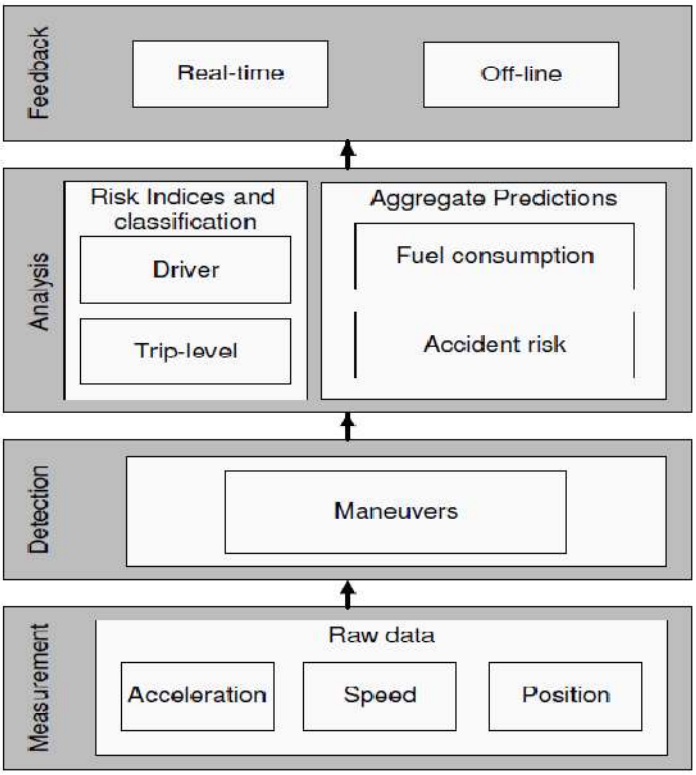

Fig.3: IVDR system [XXV]

In this model, the sensor units with advanced features are fixed to the vehicle. During the measurement phase, acceleration of the vehicle, locations, speed of the vehicle, start and end time of the trip are monitored. In detection phase, typical maneuver types such as sudden braking, high acceleration, and lane shift are observed. In the analysis phase, various driving risk factors are calculated using the results of previous stage. Risk index is calculated as follows :

$$R_{it} = \frac{\sum_{j}\sum_{s} \beta_{js} N_{ijst}}{DT_{it}} \quad (1)$$

Where

R_{it} is the risk index for person 'i' during time 't'

B_{js} denotes weights of different maneuvers

N_{ijst} specifies the number of maneuvers of type 'j' with driving severity 's'.

DT_{it} shows total driving time.

Based on the output of the risk index, the performance and behavior of driver is assessed. The final stage offers feedback about the overall assessment and the results are documented.

In order to sustain driver safety, a novel driving system with modern technique is introduced. The automated system will track the lane changeswith alarming system that points out accident prone areas. Innovative features such as automated lighting, adaptive cruise control, emergency braking, weather notification and rear view of images during parking should help the drivers in maintaining road safety. The drivers' drowsiness can be detected by the physiological changes. Advanced sensors can detect such changes more accurately. Changes in eye pattern and facial alteration will give sufficient behavioral modification of the driver. Also heart rate and EEG monitoring will give observation about drowsiness detection.[XV]

The important factors that impact the way of driving such as the environment, issues related to automobile and drivercomponents are considered while proposing automated system that utilizes computer-vision system. Drive Safe [XIV] Smart V[XX] and EcoSmart [XXVI] are mobile applications that are used more effectively to alert the driver instantaneously. These smart phone applications play a vital role in gauging the driver behavior. Artificial intelligence and advanced machine learning algorithms can be used extensively to predict driver behavior. Thisin turn will help the society to build better safety systems for transportation purpose. The policy makers of the country can formulate better rules to combat the evils of road injuries using advanced features of data mining and machine learning.

II. Related Work

The relation between driving behavior, the driving objective, and the driver behavior is explained elaborately by [XIX]. The driver characteristics can be used in automotive industry based on three aspects, namely, the intelligent driver advisory system, the driver safety warning system, and the vehicle dynamics control system. Adaptive models that can acquire the characteristics of driver behavior in online should be addressed effectively.

Intelligent vehicle system named UTDrive is used for data acquisition by many research scholars. Data related to audio, video, brake pedal pressures and GPS information are collected for analysis. The multimodal data will be used to gather better inference and it will help to propose efficient models that improve road safety [XXII]. UTDrive model is shown in Fig.4.

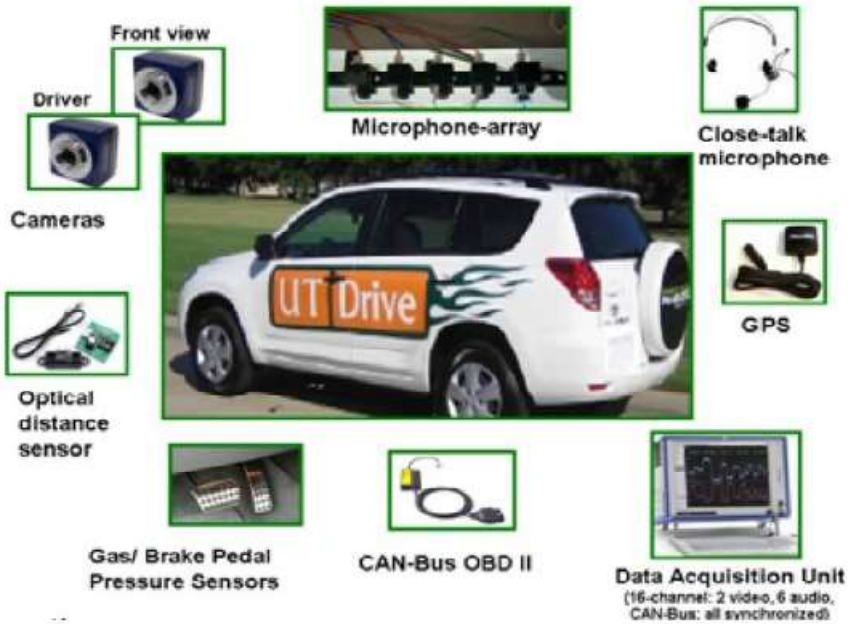

Fig.4:UTDrive model [XXII]

Traffic accident analysis is one of the critical research frontiers in the broad areas of Automobile Industry. Machine learning can be used extensively to predict the severity of accident by observing the valid patterns accumulated during fatal accidents. Logic regression based prediction model is developed by [XXIII] .The system predicts the accident severity based on factors such as roadside design, land usage and traffic devices. The results portray that city based sites are more prone to severe accidents than village sites.

Conventional linear regression models and Poisson regression models are deployed with respect to accident severity and geometric design of the roadways[XXIV] .Random and sporadic nature of the typical accidents are not correctly observed by linear regression models. The results conclude that poisson regression models are well suited in observing the much needed statistical properties. The performance of various machine learning paradigms for modeling the accident scenario is developed by [XVI]. Support vector machines, decision trees, neural network and hybrid decisiontree-neural network approach are deployed. This work used data from the national sampling system[XXI]. In hybrid approach, the efficient model reaches a training performance of 83.02% where as the testing performance shows 65.12 %.

Artificial neural networks and Support vector machine based driver analysis is carried out using sensor based data[X].Different critical parameters related to vehicle dynamics can be utilized to improve the accuracy of the model. This work shows accuracy above 90% irrespective of road condition. Driving risk prediction using machine learning techniques is one of the core areas of research. Human factors are

critical in assessing vehicle accidents. In many cases, driving safety is equated with factors such as speed, acceleration and fuel consumption. Throttle position, brake pressure are also considered as important feature in driver behavior prediction[III].

A Novel model to evaluate the driving behaviors using advanced artificial intelligence is proposed by [XXVII]. The preprocessing and cleaning of data is done and outliers are eradicated. Mean imputation is performed to fill the missing data. After preprocessing phase, feature engineering phase is initiated. Different speed ranges of the driver are taken for analysis. Speed and night driving combination can be used for better feature extraction. Neural network, random forest and SVM algorithms are used in this work. Instantaneous data is used in this study with information such as time, speed and distance reached by the automobile. The trajectory data have details such as time and GPS information. Precision,recall and F measure are used as evaluation criteria along with accuracy percentage. From the results,neural network shows better performance. Also the system with detailed attribute information on driver characteristics shows higher accuracy than the model without detailed attributes.

Driver drowsiness detection can be initiated based on behavioral measures using machine learning techniques. Level of drowsiness can be detected based on many factors such as changes in eye and head movement. Physiological measures, behavioral measures and automobile based measures are used to extract information regarding driver drowsiness. Physiological measures such as Electroencephalography are practically infeasible. Considering only the vehicle based factors are counterproductive due to heavy dependency on road conditions. But the third issue that relies on behavior factorsis very much useful in predicting driver drowsiness. A fully automated system for driver drowsiness detection is proposed by [VII]. The model utilizes Haar feature algorithm for detecting facial changes. Also classification is done using well known machine classifier namely, Support vector machine. Such method will attempt to find a hyper plane that separates training data into pre-defined classes. Hidden Markov Model is used for detecting the changes in face of driver during vehicle movement. Color and geometrical features are tracked with respect to eye movement and it is studied in [II].But this model shows better accuracy only in the indoor conditions.

Convolutional Neural Network is used widely in video analysis, and classification. A novel algorithm for driver drowsiness detection using modern machine learning method is proposed by [XIII]. Viola and Jones algorithm is used for face recognition and this model shows average performance in most of the instances. Meta-analysis of various research work related to machine learning based driver drowsiness detection is carried out [XVII].The result shows that convolutional neural networks are highly valuable in extracting better results. Also, the need for standard data set with large quantity and better benchmarking measures is highlighted by the authors.

Driver behavior analysis model using deep learning algorithm is evaluated with the help of “controller area network” based sensor data [XII]. Ocslab driving dataset

with 94,401 records [VI] is used in this study to conduct the experiments. This model is compared with other contemporary machine learning algorithms. Without feature selection, this model shows excellent results. Also the attention mechanism enables the system to learn more discriminative features.

III. Experimental Evaluation

Machine learning deploys study of algorithms that can automatically learn and improve with experience. Detection of specific patterns in the input data in an automatic fashion makes the field of Machine learning interesting and intriguing. The ML algorithms involve the concepts of statistics, probability and optimization. A novel method of Driver behavior prediction is carried out in this work using machine learning algorithms. This work deploys a binary classification model. The goal of binary classification is to classify the data points into one of two groups (either '0' or '1', true or false).

ML Algorithms Used for Driver Risk Prediction

Five machine learning algorithms are used in this work namely, Logistic regression, Multilayer perceptron, Decision tree, random forest and Naïve bayes algorithm.

Logistic regression is utilized effectively when the dependent variable is categorical in nature. A more complex cost function, called 'Sigmoid function' is used in this model.Decision tree methods develop a model of decisions made based on actual values of attributes in the data. Swiftness in predicting the output and accuracy are the positive aspects in decision trees. In such trees, nodes represent decisions and the terminal nodes with edges are binary representing the allowable paths from one node to another. Random forest involves a large number of individual decision trees that operate as an ensemble. Random forest algorithm develops decision trees on the input data and then observes the prediction from each of them. In the next stage, the algorithm selects the best solution by means of voting. Though the complexity factor affects random forest execution, the ability to overcome overfitting problem and the ability to work with large datasets make this method more feasible.Naive bayes classifier belongs to probabilistic machine learning model. Multinomial Naive Bayes, Bernoulli Naive Bayesand Gaussian Naive Bayes are the types of Naïve bayes model. When the dimensionality of the inputs are high,bayesian based algorithm will give better results[V].

Multi layer perceptron (MLP) is a type of feedforward artificial neural network model.MLP belongs to supervised learning algorithm that learns a function $f(.):R_M->R_O$ by training on a dataset, where 'M' is the number of dimensions for input and 'O' is the number of dimensions for output.The efficiency of learning non-linear models and learning capability in real time are the advantages of MLP classifier. Also, capability of generalization and high fault tolerance are the advantages of using MLP for classification process [XVIII].

Dataset Description

The dataset safe driver telematics for "Predicting Dangerous Drivers" from kaggle platform(www.kaggle.com) is used .The parameters of the dataset are 'booking ID', 'Accuracy', 'Bearing', 'acceleration', 'second', and 'Speed'.Booking ID is the trip designation given by the user.Accuracy denotes the value of specific range observed by GPS in meters.GPS bearing in degree and accelerometers reading are taken in to consideration. Gyroscope reading in X,Y and Z axis in the unit of rad/s are tabulated. Time of record and speed measurement is also inferred. The dataset contains more than 1 lakh data rows and python based implementation is carried out to extract results.

Model Execution

The execution process involves the following steps. In the initial stage ,the data collection process is initiated. The raw data is analyzed and made ready for the next step. Now the data is given to data preparation step.Here,data cleaning process such as removal of duplicates, tracking of missing values are done. In the subsequent step, splitting of training and evaluation set is performed. Using the above mentioned five algorithms, the model is trained. The model is evaluated to assess the prediction accuracy.

The execution output is depicted in Fig.5.

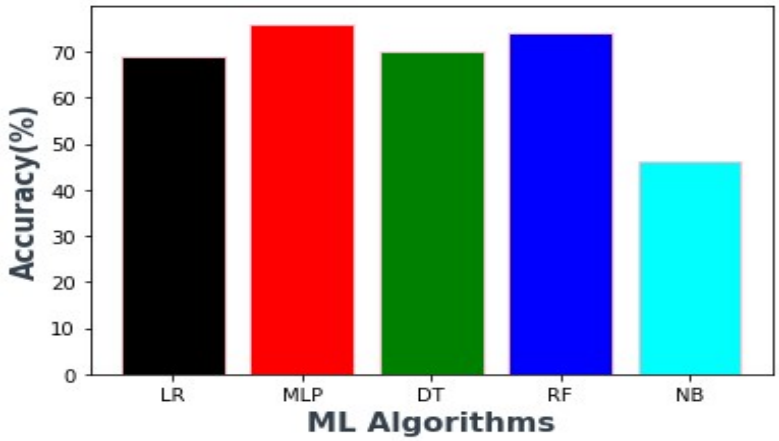

Fig.5: Accuracy performance of proposed model

The result shows the supremacy of Multilayer perceptron. This algorithm gives the best accuracy of 76%.For predicting the driver behavior to track the dangerous driving, this algorithm shows good consistency. Also, random forest algorithm comes closer to MLP performance with the accuracy of 74%.Logistic regression and decision trees offer average performance with 69% and 70% as prediction accuracy. Naivebayes is not suited for this model as it clocks less than 50% in terms of the performance factor used during the execution.

IV. Conclusion

Nowadays driving vehicles is a common phenomenon. Largenumber of accidents is happening due to driver negligence. The analysis of driver behavior using modern techniques is the need of the hour. In this paper, the prediction of driver behavior is analyzed using a prominent dataset. The results denote the versatility of multilayer perceptron model with good performance on the whole. In future, the availability of real time vehicle trajectory data can be utilized effectively to model better automated systems to predict the driver behavior. This will help the human community to conceive better traffic conditions. The road accidents can be reduced drastically by applying the results to the real time environment .Hence, it is proved that the advancement in Artificial intelligence and machine learning can be highly influential in automotive industry in the coming days.

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