International Journal of Innovative Research in Engineering & Management (IJIREM)
ISSN: 2350-0557, Volume-9, Issue-4, August 2022
https://doi.org/10.55524/ijirem.2022.9.4.5
Article ID IJIRD-1184, Pages 30-34
www.ijirem.org

A Machine Intelligent Cloud Based Framework to Monitor Driving Behavior of Vehicles Using Internet of Things

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ABSTRACT- Monitoring driving behavior of vehicles is a very important area of research in the field of Intelligent Transportation Systems (ITSs). As vehicles are rising tremendously on the roads of cities, it is very much essential to track the driving behavior of a vehicle to reduce the accidents in the cities. The drivers who are not driving properly, for example if a driver is continuously performing sudden acceleration, sudden deceleration, sudden left turn, sudden right turn, etc. then these types of vehicles need to be monitored and detected. In this work, a machine intelligent cloud-based framework is proposed to monitor the driving behavior of vehicles in the city using internet of things (IoTs). The vehicles are installed with an on-board unit which is responsible for collecting all readings from the sensors and sending these readings to cloud using IoT for detection of driving patterns. Here, the cloud is deployed with a supervised machine intelligent model that is responsible for identifying the driving pattern after receiving the readings from a vehicle. The model is selected by conducting training and testing over a standard dataset. The performance of the framework is tested using Python tool. From the results, it is found that Random Forest (RF) model performs better in identifying the accurate vehicle behavior with highest classification accuracy (CA).

KEYWORDS- Vehicle Driving Behavior Monitoring, Intelligent Transportation Systems, Machine Learning, IoT, Cloud, Classification Accuracy

I. I.INTRODUCTION

ITS has huge applications [1,2] in the field of traffic management, accident detection, safety and security, vehicular ad hoc network, IoT, etc. for providing smart city applications. As vehicles are growing day by day, the accidents are also increasing in city areas. One of the major reasons of accident is due to misbehavior of a vehicle on road [3-10]. The misbehaviors performed by the vehicles are like sudden acceleration, sudden deceleration, sudden left turn, sudden right turn, etc. If these activities are monitored continuously for a vehicle than the accidents can be controlled. Therefore, by using intelligent architectures it can be controlled. The intelligent architectures include cloud computing, IoT, machine intelligent frameworks, wireless network, etc. Cloud computing can provide services like storage, infrastructure for classification or computations, and other relevant purposes. IoT can help in sending the sensor readings from vehicles to the cloud for storage and computations. For detection of driving behavior very accurately, nowadays machine learning is an important approach in AI (artificial intelligence) [11-14]. Machine learning solves mainly problems such as classification, prediction, recognition, clustering, etc. So, in this work, we are classifying the driving behavior based on the sensor readings received in the cloud.

The main contributions in this work are represented as follows:

- In this work, a cloud-based machine intelligent framework is proposed to classify the driving behavior of vehicles using IoT.
- The vehicles are installed with an on-board unit which is responsible for collecting all readings from the sensors, and using IoT these readings are sent to the cloud for detection of driving patterns. Here, the cloud is deployed with a supervised machine intelligent model that is responsible for identifying the driving pattern after receiving the readings from a vehicle using IoT. The supervised model is selected by conducting training and testing over a standard dataset [15].
- The performance of the framework is tested using Python tool. From the results, it is found that RF model performs better in identifying the accurate vehicle behavior on roads with highest CA.

The rest of the sections are shown as follows. Section 2 presents the related work, Section 3 presents the methodology, Section 4 presents the simulation and results, Section 5 presents the conclusion and future scope, and Section 6 presents the acknowledgement.

II. RELATED WORK

Many research works are done in this area; however, some referred works are discussed as follows. Uma et al. [3] found a method for accident prevention and safety using IoT and machine intelligence models. Malik et al. [4] proposed a method for profiling driving patterns and classifying them using deep learning methods. Gyawali et al. [5] proposed a method to detect the misbehavior in vehicular network using machine learning. Gyawali et al. [6] proposed a method using reputation-based approach to detect the misbehavior in vehicular network. Grover et al. [7] proposed a method for multiple misbehavior detection in VANET using machine learning. Hu et al. [8] proposed a method for abnormal driving recognition using deep learning approach. Yardy et al. [9] detected malicious driving using machine learning. Loukas et al. [10] proposed a method to detect intruders in cyber-physical systems for VANET architecture using deep learning approach. From above study, it was found that very less work has been done in the area of cloud-based framework where the computations like classification are performed. In this work, we have proposed a framework for detecting the vehicle misbehavior using a machine intelligent cloud-based model.

III. PROPOSED FRAMEWORK

The framework mainly consists of two-tier architecture where the lower layer is device layer and upper layer is cloud layer as shown in Fig. 1. The device layer mainly consists of the vehicles (V1,V2,…Vn) moving on the roads in the city areas. The vehicle has many types of sensors for sensing the physical environment or entity. The sensors are connected to the on-board unit (OBU) in the vehicle that acts as the main control unit of the vehicle. The OBU mainly consists of sensors like accelerometer, gyroscope, etc. for reading the vehicle movement. The OBU also consist of a memory unit, transmitter, receiver, and power unit for performing different activities. We assume that the vehicle has Internet capability for uploading the sensor readings to the cloud. It sends the data to the base station (BS) near to it and from the BS the sensor readings are uploaded to the cloud for identification of driver behavior pattern. The upper layer is the cloud layer where a cloud administrator is operating the cloud for providing service to the devices. The cloud here is mainly used for storage of vehicle information in the city areas and also it is used vehicle driving pattern identification. The cloud has high computation capability whereas the vehicle has less very less computational hardware or resources. In this model, vehicle to cloud and cloud to vehicle communication uses wireless technology such as 3G/4G/LTE/Wi-MAX.

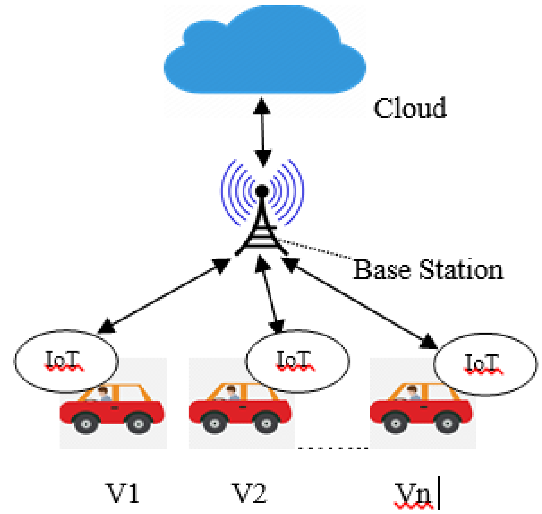

Figure. 1: System architecture framework

In this work the main driving patterns those are considered are sudden acceleration, sudden deceleration, sudden left turn, sudden right turn. If this type of activity is recognized at cloud using a supervised machine learning model, then the vehicle is warned or the vehicle is caught for taking actions.

The steps to detect the vehicle driving pattern using cloud-based framework is presented as follows:

- The vehicle starts moving on the road.
- During movement the sensors (accelerometer and gyroscope) senses the physical movements and sends the readings to the OBU.
- The OBU then sends the vehicle readings to the cloud through BS at particular interval.
- The cloud receives the readings of the vehicle and store it in the local memory. For each vehicle it maintains a local table where vehicle ID, current position, speed, direction, sensor readings, behavior, number of times performed abnormal behavior are available.
- Then the cloud uses a supervised machine learning model (Neural Network (Neural Network)/ Support Vector Machine (SVM)/ DT (Decision Tree)/ RF) to predict the actual behavior of the vehicle at the time when the readings are received.
- Here the cloud is trained with a best supervised machine learning model using a standard dataset as shown in Fig. 2.
- The best model is selected by training and testing other supervised models and selecting that model which shows high classification accuracy.
- After cloud predicts the behavior of a vehicle it counts the total number of abnormal behaviors.
- If the count is greater than a threshold then a warning message is sent to the vehicle from cloud for correct driving or any necessary action can be taken over the vehicle.

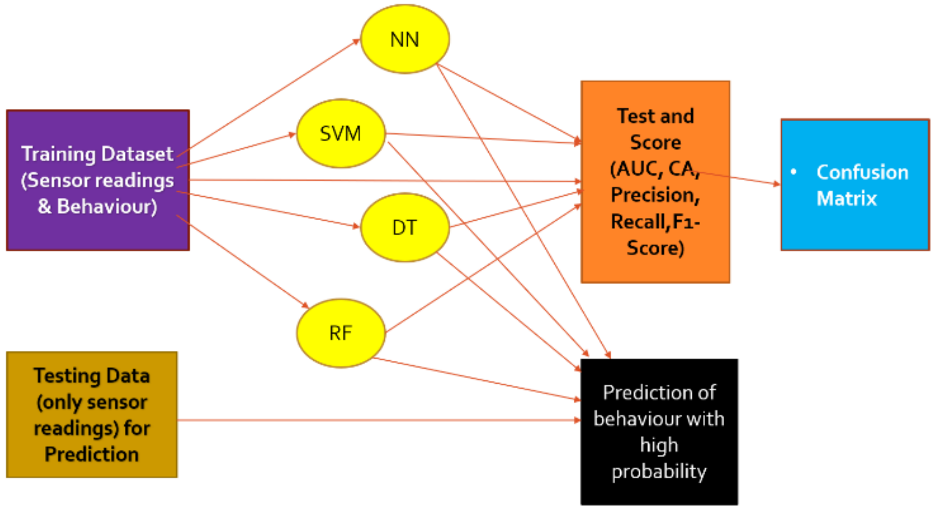

Figure. 2: Machine learning process flow

IV. SIMULATION AND RESULTS

The performance of the framework is evaluated using Python tool. The machine in which the simulation is run has 8GB RAM, windows 64-bit OS, and has a processor speed of 2.4 GHz. The models taken for this simulation are DT, SVM, RF, and NN. The performance metrics taken are AUC (area under curve), CA, F1, Precision and Recall. However, we have considered CA as the main parameter for selection of best model. In this work only the machine learning part is implemented to show the best supervised model for the cloud.

The dataset taken for this simulation is taken from Mendeley [15]. The dataset has 1114 rows and 7 attributes (columns). The 7 columns are A1, A2, A3, G1, G2, G3, and Target (1/2/3/4). Here, A is the 3 axis Accelerometer reading and G is the 3 axis Gyroscope reading. The target 1 is sudden acceleration, 2 is sudden deceleration, 3 is sudden left turn, and 4 is sudden right turn. For more information the dataset can be studied from [15].

The results are represented in Table 1 and Fig. 7 as follows. From the results it is observed that RF shows a CA of 0.65, and DT, SVM and NN show CA of 0.57, 0.45, and 0.62 respectively. Fig. 3 to Fig. 6 shows the confusion matrix of the models. The diagonal matrix shows the number of actuals that is correctly predicted.

Table 1: Comparison of performance metrics for different supervised machine learning models

Models	AUC	CA	F1	Precision	Recall
DT	0.718	0.579	0.579	0.580	0.579
SVM	0.737	0.451	0.431	0.451	0.451
RF	0.867	0.650	0.649	0.650	0.650
NN	0.854	0.620	0.617	0.617	0.620

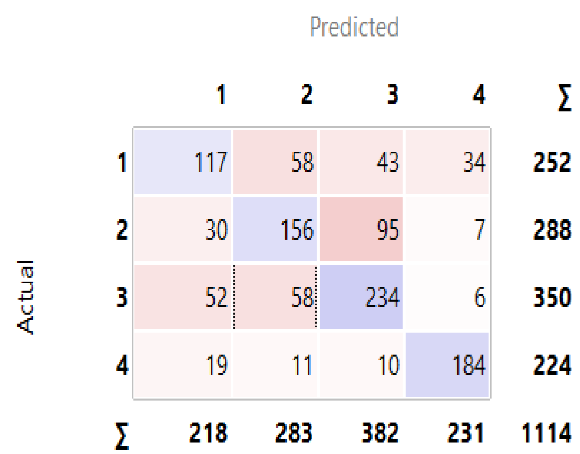

Figure. 3: Confusion matrix of NN

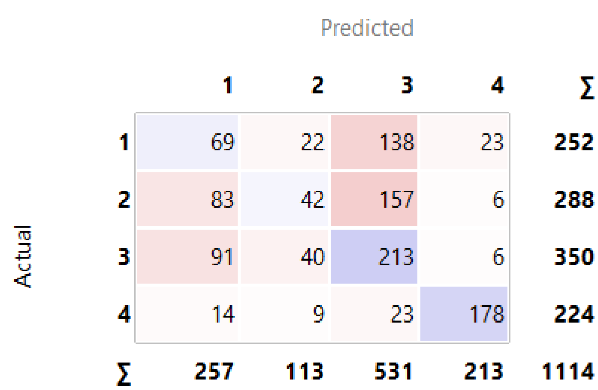

Figure. 4: Confusion matrix of SVM

Predicted (columns) / Actual (rows)

	1	2	3	4	Σ
1	102	52	65	33	252
2	53	175	52	8	288
3	66	69	202	13	350
4	32	11	15	166	224
Σ	253	307	334	220	1114

Figure. 5: Confusion matrix of DT

Predicted (columns) / Actual (rows)

	1	2	3	4	Σ
1	126	40	61	25	252
2	39	177	66	6	288
3	62	55	230	3	350
4	28	6	14	176	224
Σ	255	278	371	210	1114

Figure. 6: Confusion matrix of RF

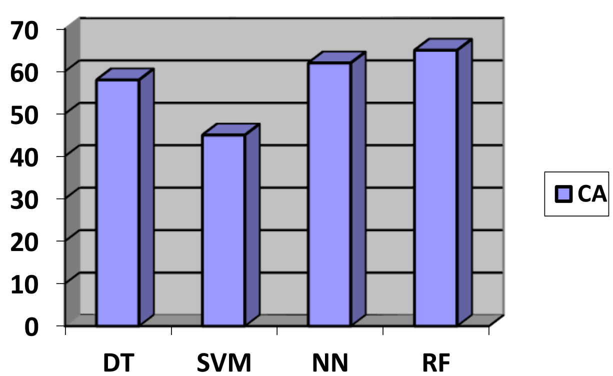

Figure. 7: CA representation of four models

V. CONCLUSION

In this work, a machine intelligent cloud-based framework is proposed to monitor the driving behavior of vehicles in the city using IoTs. The performance of the framework is tested using Python. From the results it is found that RF model performs better in identifying the accurate driving behavior of a vehicle with highest CA. In future, we will try to enhance the CA by using new supervised models and hybrid models. Also, we can use deep learning models by using large datasets on this problem.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

ACKNOWLEDGMENTS

Our thanks to Srinivas University, Mangaluru, India for giving facility to conduct this post doctoral research work in the area of IoT based vehicle driving pattern monitoring using machine learning.

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