A PREDICTIVE DECISION MODEL FOR AN EFFICIENT DETECTION OF ABNORMAL DRIVER BEHAVIOR IN INTELLIGENT TRANSPORT SYSTEM

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ABSTRACT

More than 80 percentages of road accidents happen due to abnormal driver behavior. The most vital aspect of the Intelligent Transport System is driver behavior. Edge devices communicate with their information using the communication technologies it is improves the efficiency detecting the abnormal driver behavior. In proposed work Internal vehicle, Neighbor vehicle and External parameters are analyzed to find out the driver behavior and predict the abnormality. The proposed work which uses the ITS system along with the various parameters to predict a driver behavior of its neighboring vehicle helps in reducing the road accidents. The proposed work was simulated using SUMO environment. In the realistic environment of the Chennai metropolitan city and it is observed that the proposed work provides an efficient detection of the driver behavior.

INTRODUCTION

The Road safety applications uses the techniques of mobile computing and wireless communication to improve the intelligent transport systems (ITS) (Sumalee, A., 2018) Vehicular Adhoc Network (VANET) (Lee, M., 2021) is one of the components of ITS, which allow the vehicles to communicate with each other within the locality using dedicated Short Range Communication (DSRC). The safety Application in VANET helps to improve the safety of road, prevent from the occurrence of accident by improving the traffic efficiency and warn for violating traffic signals (Sun, P., 2020). Many research scholars focus on detecting the status of driver and the vehicle. Few works to stopover the accident, by focusing on both the vehicle and the driving force and try to detect the status of the driving force. However, to monitor the state of the vehicle and behavior of the driver there is no inclusive system is found (Kong, X., 2020) . To avoid accidents by alerting or broadcasting a message in time with nearby vehicle's that found within the range, there is no proper system is found even after finding a changeover in driver behavior or vehicle behavior.

The driver can adapt the situation by accelerate or decelerate based on the traffic and the estimation of vehicle's acceleration/deceleration cannot be evaluated. From the time of collision, the driver perceives its forgoing vehicle and evaluates the difference between velocity and space, therefore the estimate is inaccurate (Thiemann, C., 2008). The spatiotemporal anticipation cancels the person's driver wholly or partially. The behavior of the driver's position is further ahead of neighbors. The expectation between the distance of the inter vehicle and differences of long term velocity are limited based on the estimated error and reaction .The driver's response time is always

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headway (around 0.3-1.5s) (Huang, J., 2008). In case of accident between the following vehicle's a series of collisions will occur. The Spatiotemporal anticipation is limited to avoid accident by expecting the behavior of non-immediate nearby vehicles. The remote anticipation may vary from driver to driver on the back-to-back collisions. The situation depends on time to time, driver to driver, and may also vary on traffic stability on the road. The feedback system is required to extend the traffic situation from the neighborhood to allow accurate estimation of traffic statistics and predictions. To enhance the stability of traffic and safety, estimation and prognosis parameters used are accurate and equal to all the vehicles in the region to provide sufficient maneuvering time to react. The traffic details among the vehicles are been distributed by VANET. The VANETs efficiency must be tested on behavior of the driver and several traffic conditions. In proposed work the driver behavior was predicted with three major parameters like internal vehicle data, neighbor vehicle data and external data. For prediction the driver behavior the system using objective function for the parameters with various ranges finally decision was taken based on the cumulative value of the functions whether the driver has normal or abnormal driver behavior.

RELATED WORK

The four categories of driving behavior are Normal behavior, Drunk behavior, Fatigue behavior, Reckless behavior (Kaplan, S., 2015). When the driver drives the vehicle by opening his eyes, maintaining the distance between the neighbors, no consumption of alcohol and monitoring the speed of the vehicle properly, then behavior of the person is estimate as normal. The drunk behavior is analyzed by accidental rushing and driving with closed eyes by not maintaining the speed of vehicle more than 80% of time period. The Driver characteristics is also analyzed when driving the vehicle with alcohol consumption with closed and not maintaining the traffic lane position.

The Fatigue behavior reveals the characteristics as drunk driving but without alcoholism. This is related to the driving with low energy (Jackson, P., 2011). The driver drive the vehicle with no sleep for a period of 17 hours, his behavior will be exactly as a person drive the vehicle with alcohol consumption of 0.05%. A driver when drives the vehicle with no sleep after a period of 24 hours, then his behavior resembles as like the person who has 0.1% intoxication of alcohol. The Reckless behavior is analyzed when the driver drives the vehicle without maintaining proper traffic lane position with eyes opened. The driver drives even at high speed, high rushing of vehicle and place the neighbors within the region in danger. This is analyzed when there is no alcoholism inside the person.

Keeping road safety in mind, it's logical to look for alternative sites for decreased hitting vehicle. Being programmable Smartphones have good display of sensors which is used for transport studies (Such as digital compass, gyroscope, accelerometer, GPS, camera, and microphone) and also to enable the sensing applications, without user engagement (Mantouka, E. G., 2018) To estimate the driver behavior some of the measurements are used single or together. This relates with behavior of vehicle, time period, space travelled and mode of driving, etc. In scientific literature the most vital parameters for unsafe or aggressive driving style assessment appears to be longitudinal and lateral accelerations and decelerations (Singh, S. 2015) (Theofilatos,

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A. 2017). When the event was occurred the different frequencies are observed and the observations are explained to the traffic within the city that needs more sharper turns, acceleration and decelerations (Paefgen, J, 2012). Further researchers found more hostile behaviors within the area by analyzing high traffic flow within the city, where few observed that it can be classified as suburban sub urban (Vaiana, R., 2014)

The feedback method helps to record the driving behavior either from the sensor inside the vehicle or by the smartphone sensors, and also collect the high resolution data to inform the driving style of the driver. When compared to other technology this research shown that the drivers accept feedback easily (Toledo, T., 2008). Significant correlations have been discovered between vehicle-related recording systems and, as a result, smartphone sensors, despite the fact that they are influenced by the type of event, the smartphone's location in relation to the car and external elements (Roetting, M., 2003). The development of application for smart phone has saved the cost of putting in and operating a system unit inside the vehicle for collection of data to support.

PROPOSED WORK

The proposed system takes input from three main parameters such as Internal vehicle, Neighbor vehicle, External conditions. In these parameters its observed that totally eleven parameters are taken to finally drive at the behavior status of the driver. The first and most important parameter which is consider is internal vehicle. Which contains very highly sensitive information for driver behavior analysis like input from Vehicle position, Speed, Eye camera, Alcohol sensor, Lane camera. Secondly in the proposed system consider the neighbor vehicle associated parameters like NV position, NV speed and Direction. It contributes in less determination of the driver behavior as compared to the internal vehicle parameters. Finally, the external parameters like Weather, Road condition, Traffic is considered for driver behavior analysis similar to the neighbor vehicle parameters it contributes less in determining the driver behavior as compared to the internal vehicle parameters.

Internal Vehicle Parameters

The vehicle position parameter, which is represented as $\alpha 1$, gives the exact position of the vehicle based on the Global Positioning System (GPS) this parameter gains equal weightage with other parameters of internal vehicle. There will be a drastic change in the position of the vehicle within short interval of time. Abnormal driver behavior directly proportional to the drastic change in the vehicle position denoted by α_1. The speed is an important parameter among internal vehicle parameters which is represents α_2. This parameter is vital in finding out the abnormal behavior of a driver. The data collected from the speedometer if it is observed the sudden spike in the difference of speed then it may lead to an accident occurring in this place. So this parameter has to be keenly observed to find out the abnormal driver behavior if any. The next parameter driver face monitoring represented by the notation α_3. This parameter helps in constant monitoring of face especially eye to find out the exact state of the driver whether his drowse or sleeping while his driving the vehicle. More weightage is given to this parameter during night travel where there is more probability of accidents due to driver sleeping. Next vital parameter which is consider is

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alcohol consumption. This parameter gives as the information whether the driver as consumed alcohol or not. When it is found the driver as consume the alcohol the information has to be communicated to the neighbors immediately since there are in high risk of accident. This parameter is represented as α_4. The final parameter which is consider the internal vehicle parameter is lane monitoring which is represented using notation α_5. This parameter is observed with the help of lane camera with the constant observation of lane camera if it is observed the vehicle might change the lane information has to be communicated to the neighbor to avoid accident.

Objective function for Internal Vehicle Parameters (IVP(x)),

$$\text{IVP(x)}=\begin{cases} 1, & 90 < x < 100;\ 1 \\ \frac{x}{100}, & 70 < x \le 90;\ 0.7 \text{ to } .9 \\ \frac{0.4x-14}{20}, & 50 < x \le 70;\ .3 \text{ to } 0.7 \\ \frac{0.x-2}{10}, & 30 < x \le 50;\ .1 \text{ to } .3 \\ 0, & 0 \le X \le 30, 0 \end{cases} \qquad (1)$$

Table 1: Internal Vehicle Parameter values with Objective function range

S No	Parameter Notation	Parameter Values	Objective function range
1	α_1 Number of position changes	0 to 2	70 to 90
		2 to 4	50 to 70
		4 to 6	30 to 70
		Above 6	0 to 30
2	α_2 Speed (km/hr)	0 to 20	0 to 30
		20 to 40	30 to 50
		40 to 80	90 to 100
		80 to 100	50 to 70
		Above 100	0 to 30
3	α_3	Sleeeping	0
		Not sleeping	100
4	α_4	Alchol consumed	0
		Alchol not consumed	100
5	α_5 Number of changes in lane	0 to 1	90 to 100
		2 to 3	50 to 70
		Above 3	0 to 30

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Hypothesis 1

Around the 1000 vehicles for the internal parameter values are taken and applied to the Objective function IVP(x) checking every range of the function whether the chosen objective function provides the optimal output.

H_0: $\tau_2 \in 50 < x \leq 70$

H_1: $\tau_2 \notin 50 < x \leq 70$

Where τ_2=(0.4x-14)/20 objective function by applying the hypothesis it is found that τ_2 is accepted by getting the t-value as 1.87 which gives as the confidence level of 95 percenatge and the null hypothesis H_0 is accepted and τ_2 which doesnot belongs to the range $50 < x \leq 70$ is rejected

Hypothesis 2

H_0: $\tau_1 \in 30 < x \leq 50$

H_1: $\tau_1 \notin 30 < x \leq 50$

Where τ_1=(0.x-2)/10 is the first range of the objective function. Here the hypotheis is applied in the range of 30 to 50 percenatge. While applying the statristical testing it obtains 1.91 and it is found that it achives the confidance level of 95%. so which proves that null hypothesis H_0 is accepted and the hypotheisis H_1 which sates that the objective function which does not belongs do this range is rejected.

Hypothesis 3

H_0: $\tau_3 \in 70 < x \leq 90$

H_1: $\tau_3 \notin 70 < x \leq 90$

Where τ_3=(0.0x) objective function is checked with two hypothesis H_0 and H_1 where H_0 belongs to the range between 70 to 90 on the other hand H_1 does not belongs to the range given in H_0. While applying the statistical testing it is found that its obtain the t value of 1.68 based on that it achives the confidance level of 90 percentage. Since the confidance level is around 90% the H_0 null hypothesis is accepted. The hypothesis H_1 is rejected which doesnot belongs to this range while applying this objective function.

From the above statistical analysis it is found that τ_1,τ_2 and τ_3 satisfies the null hypothesis and it works well for there different ranges given.

Neighbor vehicle Parameters

The neighbor vehicle parameters help our system to provide the accurate driver behavior. Because the neighbor behavior determines the accurate status of the driver behavior. The neighbor vehicle parameters as a huge influence on driver behavior since the malicious driver behavior of the driver may cause unexpected accidents. It also determines change in internal vehicle position, speed and direction as discussed in internal vehicle parameters. The parameter neighbor vehicle position (β_1) determines not only the position of the vehicle, which is referred, but also the position of the close by neighboring vehicles. It is found to be the key feature in case of sudden change in position may led to number of changes in the neighboring vehicles. Secondly, the next parameter

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considered here is neighbor vehicle speed (β2). This parameter helps as to find out safety of the neighboring vehicles. Sudden increase or decreases in the speed due to various parameters like sudden failure in the vehicle or unexpected crossing of any vehicle, human or animal may cause an accident and change the behavior of close by vehicles. The final parameter of neighbor vehicle parameters is direction (β_3). This is the necessary parameter which determines the change in the direction of the neighbor vehicles. The sudden change in the direction of vehicle will affect the direction of the neighbor vehicle. It is very much necessary to consider this parameter since this may affect the behavior of its neighbor vehicle driver.

$$\text{NVP}(x) = \begin{cases} 1, & 80 < x < 100; \\ \frac{0.3x-6}{20}, & 60 < x \leq 80; \\ \frac{0.2x-3}{15}, & 30 < x \leq 60; \\ 0, & X \leq 30 \end{cases} \tag{2}$$

Table 2: Neighbor vehicle Parameter values with Objective function range

S No	Parameter Notation	Parameter Values	Objective function range
1	β_1	Number of changes 0 to 2	80 to 100
		2 to 5	60 to 80
		5 to 7	30 to 60
		Above 7	0 to 30
2	β_2	0 to 60	80 to 100
		60 to 100	60 to 80
		Above 100	0 to 30
3	β_3 Suddenly chnaging the direction	less than 2 times	60 to 80
		2 to 4	30 to 60
		More than 4	0 to 30

Hypothesis 4

H_0: $\tau_1 \in 30 < x \leq 60$

H_1: $\tau_1 \notin 30 < x \leq 60$

Where τ_1=(0.2x-3)/15 objective function is checked with two hypothesis H_0 and H_1. While applying the statistical testing its obtain the t value of 1.9 based on that it achives the confidance level of 95 percentage. H_0 null hypothesis which belongs to the range 30 to 60 is accepted. The hypothesis H_1 is rejected while applying this objective function.

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Hypothesis 5

H_0: $\tau_2 \in 60 < x \leq 80$

H_1: $\tau_2 \notin 60 < x \leq 80$

Where τ_2=(0.3x-6)/20 objective function with in the range 60 to 80. While appliying the hypothesis it is found that t value is 1.86. From this statistical value τ_2 is accepted with the confidence level of 95%.

External Parameters

External parameter may influence the driver behavior to some extent. It may have greater influence at the time on the worsen scenario and it may have a very little influence in case of moderate scenario. First and foremost, parameter considered here in the external parameter is weather condition denoted by μ_1. This parameter depends upon the climatic condition of a given location. The behavior of the driver may change according to the weather of a given place like in case of heavy rain, fog mixed with smoke may lead to reduce visibility which in turn leads to change in speed and direction. Similarly, the parameter road condition (μ_2) based on the severity of the pits on the road the behavior of the driver changes accordingly. With the sudden change in speed and direction of the vehicle which may lead to an occurrence an unnecessary accident. The final parameter listed in the external parameter is that traffic information (μ_3). This parameter is a very useful parameter used by the driver to plan a better solution to reach the destination with less difficulty.

$$\mathrm{Ext(x)} = \begin{cases} 1, & 80 < x < 100; \\ \frac{0.2x-7}{10}, & 60 < x \leq 80; \\ \frac{0.x-1}{10}, & 30 < x \leq 60; \\ 0, & X \leq 30 \end{cases} \quad (3)$$

Table 3: External Parameter values with Objective function range

S No	Parameter Notation	Parameter Values	Objective function range
1	μ_1 (Weather)	Normal	80 to 100
		Medium	60 to 80
		Worst	30 to 60
		Very Worst	0 to 30
2	μ_2 (Road Condition)	Normal	80 to 100
		Medium	60 to 80
		Worst	30 to 60
		Very Worst	0 to 30
3		Normal	80 to 100

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	μ_3(Traffic condition)	Medium	60 to 80
		Worst	30 to 60
		Very Worst	0 to 30

Hypothesis 6

H_0: $\tau_1 \in 30 < x \leq 60$

H_1: $\tau_1 \notin 30 < x \leq 60$

Where $\tau_1=(0.x-1)/10$ which is the objective function is applied in the statistical testing where H_0 belongs to the range is 30 to 60 and H_1 doesnot belongs to the given range with respect to the given objective function. Out of the satistical messure the t value is obtain as 1.7 and the confidance level of 90 percentage is achived for the hypothesis H_0. Show its prove that H_1 is rejected it doesnot belongs to the range 30 to 60 and inturn H_0 is accepted.

Hypothesis 7

H_0: $\tau_2 \in 60 < x \leq 80$

H_1: $\tau_2 \notin 60 < x \leq 80$

Where $\tau_3=(0.2x-7)/10$ objective function with in the range 60 to 80. While appliying the hypothesis it is found that t value is 1.89. From this statistical value τ_2 is accepted with the confidence level of 95%.

SIMULATION RESULTS

The proposed system applied on a simulation where radius of 6KM in a high traffic zone at the center of the Chennai city in Figure1. The proposed model is evaluated with 1000 vehicle movements in the given 6KM radius, which runs up to 12KM. The total length of the road where all these vehicles move is 25KM. The various parameters of the proposed system like vehicle position, speed, eye camera, alcohol sensor, lane camera, NV position, NV speed and Direction, weather, road condition and traffic condition are considered and the proposed model gives as the number of abnormal drivers based on the parameters considered. Similarly, we also find out normal driver based on the parameters applied by the proposed system. It is evident from the results that it more accurately detects the abnormal driver behavior and it useful for avoiding the accidents.

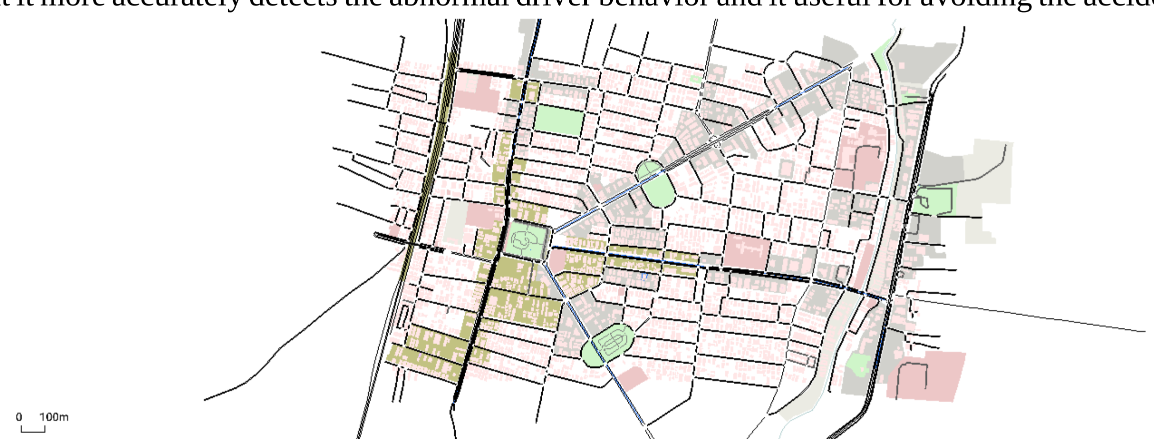

FIGURE 1:
CHENNAI CITY MAP IN SUMO

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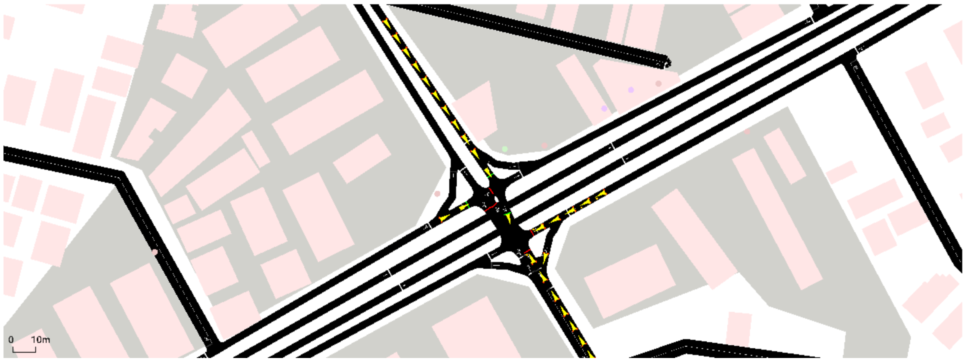

FIGURE 2:
VEHICLE MOVEMENTS IN HIGH TRAFFIC ROADS

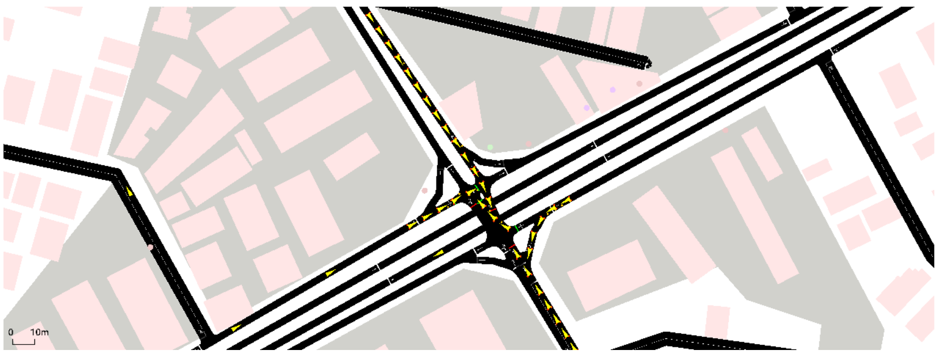

FIGURE 3:
TRAFFIC CONJUNCTION

Figure 2 gives as the traffic status while the normal drivers are driving the vehicle. In Figure 3 it is evident because of the abnormal behavior of the driver which has caused traffic conjunction and associated problem of it.

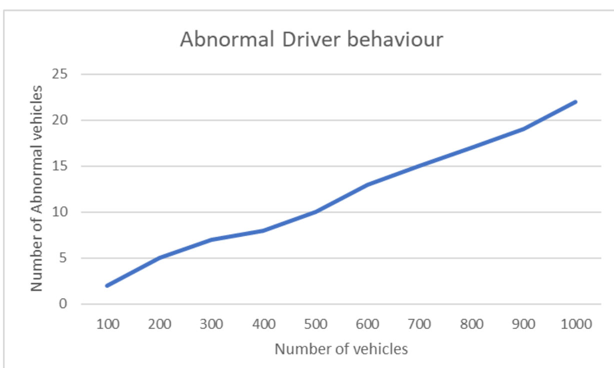

FIGURE 4:
NUMBER OF NORMAL DRIVER VS ABNORMAL DRIVERS

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In Figure 4 provides the inference of the abnormal driver behavior from the simulated environment fed with the proposed system. It is evident that the proposed system detects abnormal driver behavior based on decision taken from the proposed model.

CONCLUSION

A VANET simulation using SUMO where the realistic vehicular movement is modeled. The proposed model considers three different parameters which has sub parameters is applied with the objective function at each objective function tested with the statistical analysis which in turn provides as an efficient detection of abnormal drivers. With the efficient detection of abnormal drivers using the VANET communication of the proposed model it is able to predict the occurrence of the accidents and able to provide the normal drivers the abnormality of the neighboring vehicle.

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