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Prediction of Vehicle Collision Probablity at Intersection using V2V Communication

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Abstract — Increasing numbers of vehicles on the road are adding to the problems associated with road traffic. Efficient monitoring of vehicles is need of time for smooth traffic flow. Vehicle collision detection and congestion control are prime challenges to be met. Many technologies are in action for collision free traffic. Pertaining to this, vehicle collision prediction system based on VANET is proposed which addresses the issue of collision avoidance. It uses Intelligent Control Unit (ICU) and Vehicle to Vehicle communication to predict the collision probability at highway intersection. The scheme is implemented at open street map, on location of interest and makes use of warning system based on collision probabilities.Simulation results show the collision probability for near crash, no crash and crash.

Index Terms— Collision Prediction, Collision Probability, Intelligent Control Unit, VANET, Vehicle to V ehicle Commuinication.

1 INTRODUCTION

In today's world, the number of vehicles is increasing; creating colossal traffic and more chances of any type of accidents [1]. India is one of the leading countries in the world with over a million kilometre of road network with intersections. These roads make an imperative contribution to India's cutback. Thus the facilities for the road users which are not up to the mark, results in high charge of the death fatalities.

Recently, high road crash problem has raised various concern regarding the vehicular safety [2][3]. Thus, developing a collision warning system is of great importance that is capable of preventing accidents regardless of unexpected conditions. Vehicular ad hoc networks (VANET) which is considered as a special case for mobile ad hoc networks (MANET), a hot topic in recent years for the development of Collision Warning System.[4][5]Collision Warning Systems (CWSs) are used to avoid potential collisions and spread safety notifications amongst nearby vehicles [6][7].

The problem of designing efficient and effective warning systems has been widely studied. This involves design of warning systems that are capable of acting proactively before an accident takes place, or spreading post crash messages for avoiding further collisions, or both [7][8].

A VANET can't predict when nodes in the system have a high dynamic characteristics and a special demand for low delay. Due to this, the safety system within the intelligent transportation systems (ITS) has attracted a lot of interests in how to decrease the number of accidents in highway scenario using wireless data communication.ITS is dedicated to improve transportation safety. ITS can be generally divided into intelligent infrastructure systems and intelligent motor vehicle systems. Intelligent transportation systems consist of the backbone management system such as a transportation management centre, and communication points to vehicles such as Road Side Units (RSUs) [9].

The VANET provides a more effective way for vehicle to vehicle communication, vehicle to road side communication, sharing of information within each other, etc. In-order to make the maximum utilization of the VANET capabilities, an efficient accident prediction scheme must be designed according to the requirement of the system to avoid the accident . The present schemes cannot meet the requirements of the future due to enhancement in VANET which require more sophisticated schemes. The policy must be able to provide more efficiency when implemented in VANET providing more safety and lesser complication in communication and prediction of collision at intersection.

The proposed scheme provides us with capabilities of predicting the chances of collision on highway with the use of vehicle-to-vehicle communication by means of RSU communication. The RSU will continuously monitor the location of vehicles in its range and also keep track of the information about these vehicles. Having the current information about the vehicles, RSU will calculate the collision probability of the vehicles approaching towards the accidental zone. Depending upon the information stored and comparing this value with the threshold, the criticality of situation is calculated. The RSU will send warning messages to the corresponding vehicle which is in danger.

The rest of the paper is organized as follows, Section II problem statement. Section III discusses about proposed design, Section IV briefs about analysis of proposed scheme, Section V shows experimental results and Section VI concludes the paper. The simulation was carried out through SUMO simulator by increasing the number of vehicles.

2 LITERATURE SURVEY

Traditional collision warning system is developed based on the concept of Intelligent Transportation System. The aim of this paper is to find effectiveness of collision warning system and predict the probability of possible collision based on VANET.

A Differential Global Positioning System (ADGPS) based on vehicle-to-vehicle collision warning system is introduced by H. Tan [10] which requires a simple GPS unit and basic motion sensors to detect a possible collision situation. This system predicts the danger situation using the information of nearby vehicles to provide safety but it invariably

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covers a very small area around the vehicle so it cannot support traffic leading applications.

Lung-Chihet al [9] proposed clustering system for intersection collision avoidance service as an alternative to DSRC. Formation of cluster is done using Wi-Fi peer to peer channels while the LTE channels are implemented for transmitting the Cooperative Awareness Messages (CAMs). A channel allocation algorithm is also implemented between different clusters that help in reducing the interference of Wi-Fi channels. The performance of the Heterogeneous architecture is not better in terms of the delivery rate as compared to other schemes.

In [11] author proposed Collision Avoidance System which makes use of the latest road information more frequently and provides it to the drivers after detection of traffic density by the safety application in its critical range. Collision avoidance system is fixed in danger zone on road side. It generates an emergency message and transmits it to the drivers, before the vehicle reach the potential danger zone. The proposed model is simulated in ns2 and output is shown by using network animator.

Stefan et al [12] commented on Collision Avoidance System at intersections as ITS application. A scheme is developed to determine vehicle collision probability at typical suburban X-intersection by means of Inter-vehicular communication concepts. In addition to this, a novel scheme is proposed to quantify future crash probability at intersection, which is based on the situation in which a vehicle receives beacon message known as Basic Safety Message (BSM). Presented scheme makes use of Intelligent Driver Model (IDM), the car-following model. VEINS, SUMO and OMNET++ simulator is used to validate the proposed scheme.

In [13] author proposed a vehicle trajectory collision warning system based on Vehicle Infrastructure Integration (VII) system in order to improve the traffic safety. V2V wireless communication is used to predict trajectory. Vehicle collision can be detected in real time by the collision detection algorithm which is also a part of the interest. As to judge collision risk time to collision (TTC) is calculated and the system is able to create a warning to driver according to the value of TTC.

In [14] the author proposed an active collision avoidance system which could provide a safer lane changing strategies with self-steering in presence of moving vehicles with uncertainties. The system uses a model predictive control system which could help to predict the future positions of the vehicles and thus can help to reduce the risks of collision. This system also uses the capabilities of DSRC techniques for information gathering to detect the conflicts. The proposed system ensures the accuracy and safety of the control of the steering of the autonomous vehicles using the uncertainties that are associated with the moving vehicles and the network time delay.

Gabriel R. de Campos, et al [15], implemented an efficient frontal collision detection and prevention system. In this, Kalman filter is used as motion prediction algorithm which is a reach ability-based decision-making protocol that enables an emergency intervention. The simulation results which are based on realistic data obtained specifically for this scenario are also presented showing the efficiency and the potential of the proposed solution.

3 Problem Statement

Most of the vehicle collision avoidance systems developed is based on ITS concept. Previously Vehicular networking, safety-enhancing protocols and applications are only evaluated based on delays and packet loss rates that form the networking metrics. Vehicular networking can be evaluated using safety metrics i.e. in terms of traffic safety. So proposed evaluation scheme will quantify the probability of a crash by continuously monitoring and transmitting the beacon message to the possibly colliding vehicles. The concept of beacon message and co-operative awareness message is to be used to determine the metrics to achieve active safety system. Based on calculated metric the criticality of situation is differentiated and depending upon this, the alert message will be send to the potential danger vehicles.

4 Proposed Scheme

The proposed scheme uses V2V communication by means of Intelligent Control Unit to predict the collision probability at highway intersection.

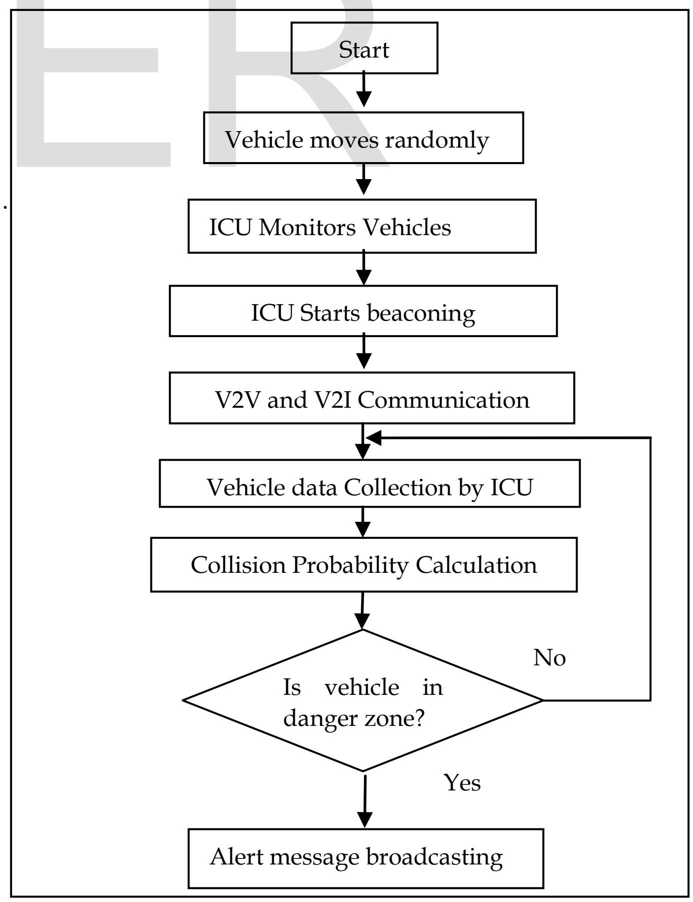

Fig 1.Overview of proposed system

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The proposed scheme provides us with capabilities of predicting the chances of collision on highway with the use of vehicle-to-vehicle communication by means of ICU communication. First part deals with the road network creation in SUMO and places ICU near intersection. The ICU will start monitoring the location of vehicles in its range and also keep track of the information about these vehicles. Having the current information about the vehicles, ICU will calculate the collision probability of the vehicles approaching towards the accidental zone. Depending upon the information stored and calculated future path of the vehicles the criticality of situation is calculated. The ICU will broadcast alert messages to the corresponding vehicle which are in danger.

5 Assumptions

Some of the assumptions that are considered for the proposed scheme to predict collision probability are as given below.

- ICU is stationary and computationally strong.
- It is installed at accidental zone.
- It will continuously monitor the location and have all the information of the vehicles in its vicinity.
- Information such as location and speed of each vehicle, time acquiring for data, direction of the vehicle.
- ICU will continue to provide the efficient prediction at any cost.
- It will calculate collision probability of vehicles in its vicinity.
- Vehicle to ICU communication is possible
- Vehicles have the information about the nearby vehicles.

6. Intersection collision prediction algorithm

- Vehicles move randomly near X intersection on highway.
- ICU will continuously monitor the location of vehicles in its vicinity.
- ICU will start beaconing to know the presence of vehicles in its range.
- A vehicle to vehicle communication starts when vehicles enter in ICU range.
- Vehicle information acquisition is done by ICU.
- ICU will calculate the vehicle collision probability of vehicles which are near the danger zone.
- ICU will set threshold value which may be distance or time required to cross the accidental zone.
- ICU will send the warning messages to the vehicles whose collision probability will exceed the threshold.
- ICU broadcasts alert message to vehicles.

7 Simulation Environment

To validate the proposed scheme, simulations were done using the SUMO 0.21.0, OMNET++ 4.5 and VEINS 3 which bidirectionally coupled road traffic simulator SUMO and network simulator OMNET++. It extends the MiXiM physical layer simulation framework for purposed of communications in vehicles. For simulating the proposed scheme, a typical suburban x intersection with real intersection point of interest at the location 78.9766 and 20.9178 was extracted from Open Street Map. The below figure 2 shows the exported view of open street map. The map extracted from OpenStreetMap was in OSM file format which is not supported by Sumo format so need to be converted into SUMO simulator format to create road network file. OSM file is converted to network file using NETCONVERT command which is provided by SUMO. These commands take OSM file as input to generate net.xml file. Generated net.xml file will used as input to create route file which is responsible for traffic flow.

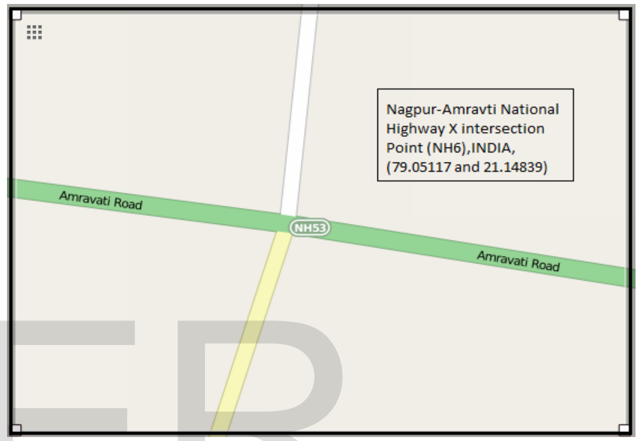

Figure.2 X intersection export from open street map (Nagpur -Amravati highway, INDIA).

To run the simulation, configuration file of SUMO is needed which includes all the name of file such as net.xml and route.xml.

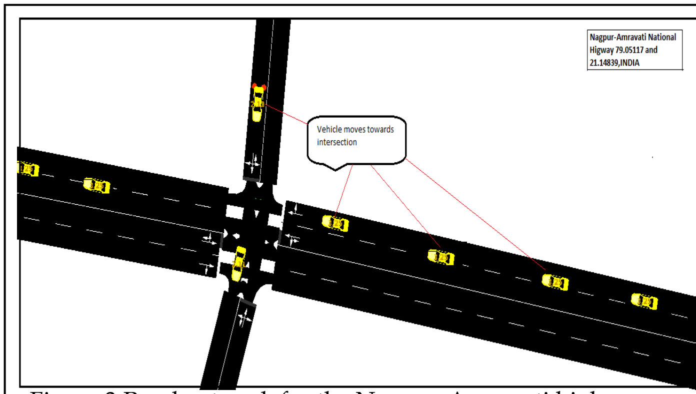

Figure 3 Road network for the Nagpur-Amravati highway scenario in SUMO

As we can in figure 3 the road network for the Nagpur-Amravati highway scenario is simulated. The road network is imported in SUMO simulator from OpenStreetMap. The vehicles are moving towards intersection.

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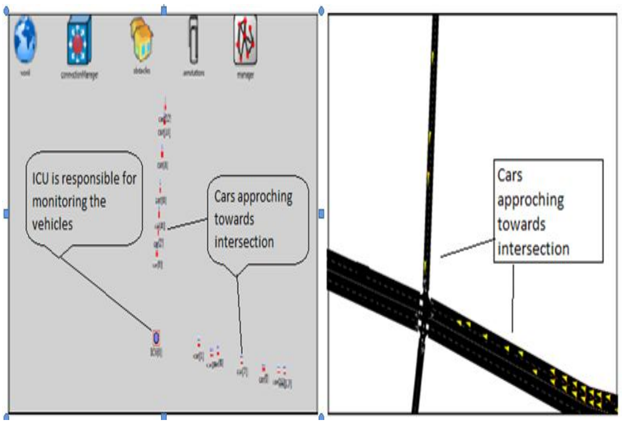

Fig 4: SUMO and OMNET++ simulator running in parallel.

Integrate Sumo and OMNeT++ simulator with the help of VEINS simulator. As shown in figure 4 the parallel execution of both the simulator after integration with VEINS. The SUMO simulator is responsible for movement of vehicles, its speed, acceleration etc. All the movements of vehicles are reflected in OMNET++ by integrating SUMO and OMNET++ with VEINS. After integration starts the simulation from OMNeT++ simulator by running omnet.ini file. Initially ICU will start beaconing for fixed interval of time to monitors the vehicles in its vicinity. After successful reception of beacon by the vehicles, vehicles start communicating with the ICU as well as other vehicles in its vicinity. Vehicles will send their information to the ICU as well as other vehicles.

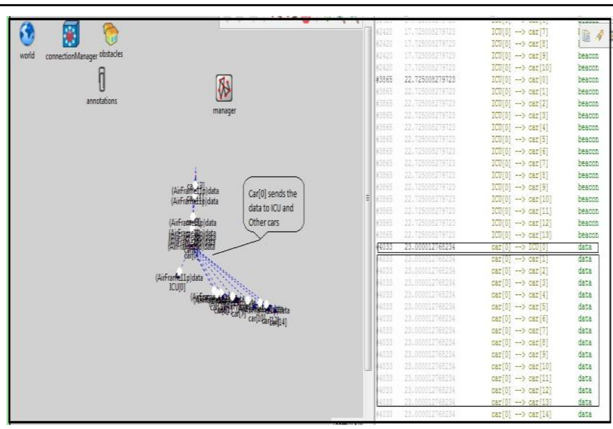

Figure 5 Vehicle-vehicle communication and vehicle to ICU communication

As in figure 5, vehicle to vehicle and vehicle to ICU communication is shown. The information exchange during communication is monitors by the ICU to find the possible future trajectory of each vehicle based on their current distance and speed bounded by their max acceleration and max deceleration is estimated. After calculated the future trajectory

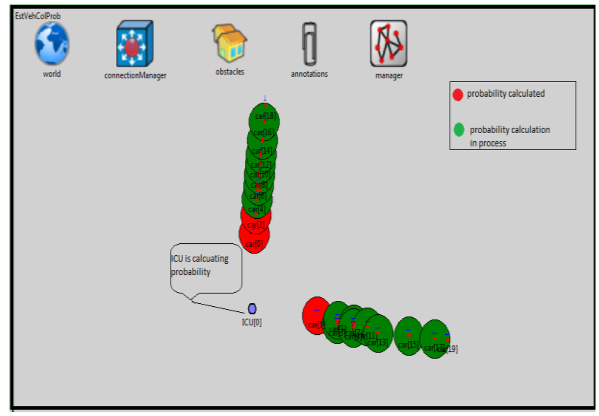

Figure 6 ICU is calculating collision probability of each vehicle

of vehicles probability of crash, near crash and no crash for each vehicle is predicted.

As figure 6 shows, the calculation of collision probability for each vehicle based on their calculated future trajectory. Red circle shows that the probability of car0, car1, car2 is calculated while the green vehicles in green circle are under process. After calculating the collision probability alert message will be broadcasted by ICU.

8 Results and Discussion

The prediction of vehicle collision probability at the intersection was simulated successfully. The simulation of the proposed system was carried out in SUMO and OMNET++, integrated together with VEINS. The outcome of the simulation shows the estimated collision probability for different situation which can be seen in the figure given below. The simulation is considered for three different groups to determine the maximum collision probability which is shown in figure 7.

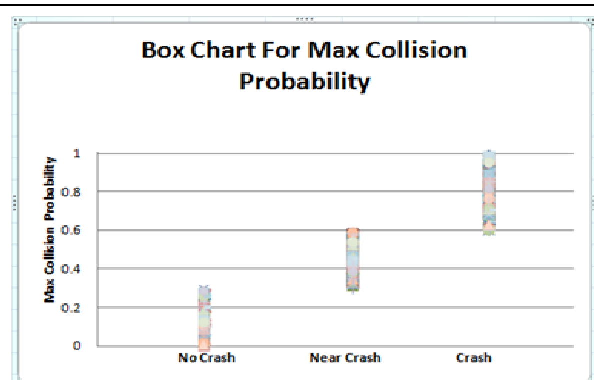

Figure 7: Box plot showing the maximum collision probability at different sections

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The first group Crash is considered to have the intersection approaching vehicles that collide at intersection. The second group is created in order to maintain the criticality of the situation and is called as Near Crash group. This group includes the intersection approaching vehicles that violated the safety range considered as 0.4 m of another vehicle. The third group No Crash includes all the other intersection approaching vehicles that neither collided nor violated the safety range of any other vehicle.

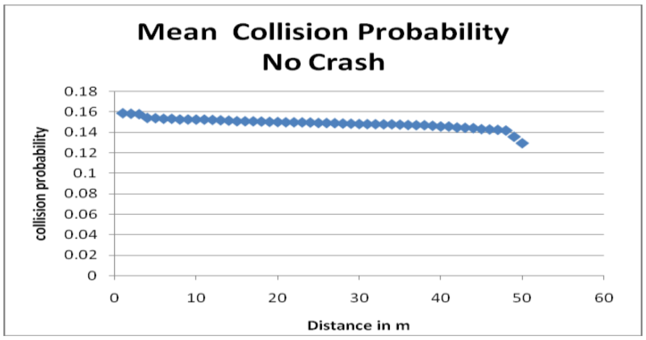

Figure 8: Mean estimated collision probability for No Crash

The simulation is considered for three different groups to determine the collision probability. The first group Crash is considered to have the intersection approaching vehicles that collide at intersection. The second group is created in order to maintain the criticality of the situation and is called as Near Crash group. This group includes the intersection approaching vehicles that violated the safety range considered as 0.4 m of another vehicle. The third group No Crash includes all the other intersection approaching vehicles that neither collided nor violated the safety range of any other vehicle.

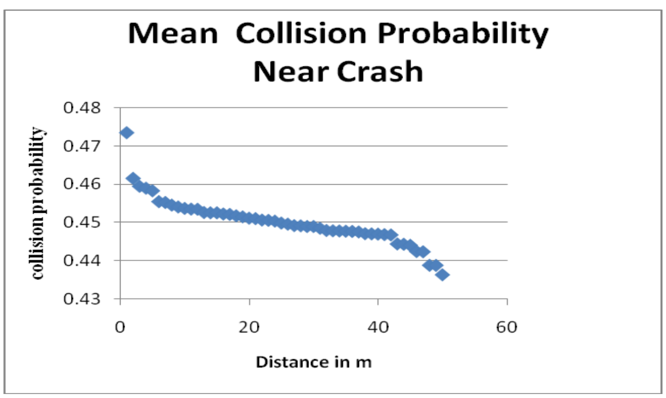

Figure 9: Mean estimated collision probability for Near Crash

Above graph gives us the collision probability for the respective distance from point of intersection for near crash. It is apparent from the graphs that the distance varies in the range from 0-50 m approximately whereas the probability is in the range of 0.43-0.47. The probability for this scenario is high as compared with no crash. Similarly the respective graph for crash is given below.

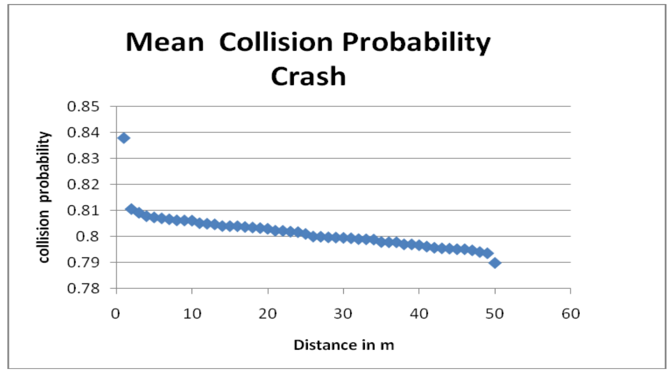

Figure 10: Mean estimated collision probability for Crash

The crash group is the most intense zone at interaction. As in above graph the collision probability is highest as compared with the near crash and no crash values. The distance varies in the range of 0-50 m approximately whereas the probability is in the range of 0.78-0.84.

9 Conclusion

In this paper, a vehicle collision detection and prediction system is presented based on ICU and IVC. This scheme has been implemented on highway intersection scenarios. Open Street Map is efficiently used for extracting and implementing the real map. SUMO, OMNET++ and VEINS provides a good environment of VANET simulations. In the proposed scheme, The ICU monitors the vehicles dynamics and calculates the probability of collisions, based on the acquired data. The ICU differentiates the criticality of the possible collision based on the distance from the intersection zone. Simulation results show the collision probability for near crash, no crash and crash. Future work intends to implement the proposed scheme in different scenarios and various locations such as Y intersection and blind curves.

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