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Design Approach for Inter Vehicular Communication in ITS

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Abstract: **-- In today's world, the number of vehicles is increasing; creating colossal traffic and more chances of any type of accidents. Efficient monitoring of vehicles is need of time for smooth traffic flow. Many technologies are in action for collision free traffic. So our focus is in using Inter-vehicular Communication(IVC) beaconing for increasing driver safety. In Previously study of Vehicular networking, safety-enhancing protocols and applications are only evaluated based on delays and packet loss rates that form the networking metrics. We present the evaluation scheme will quantify the probability of a crash by continuously monitoring and transmitting the beacon message to the possibly colliding vehicles. We investigated impact of safety messages between car approaching at intersection using road traffic simulator that allow selected vehicle to disregards traffic rules. We uses Intelligent Control Unit (ICU) and Vehicle to Vehicle communication to predict the collision probability at intersection. Our simulation results evince more details about regarding the criticality assessment of beacon messages, and as such they can be used to develop more sophisticated beaconing solutions.**

***Keywords*—vehicular ad hoc network, Intelligent Control Unit, IVC, ITS**

I. INTRODUCTION

Road accidents causes to human lives from both an injury as well as financial aspect. Manufacture have long been in the process of design vehicles based on principles of reliability and safety. however due to human errors, environmental error and negligence, accident occurs. 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. Hence the development of Collision Warning System having a great importance uses Vehicular ad hoc networks (VANET) which is considered as a special case for mobile ad hoc networks (MANET), Collision Warning Systems (CWSs) are used to avoid potential collisions and spread safety notifications amongst nearby vehicles [4]. Research on Inter vehicle communication is mainly motivated by safety and efficient application, both requiring efficient management of wireless communication channel. IVC has been achieved with standardization of IEEE802.11p protocol, still other communication technologies remain very important to the field.

The safety system within the intelligent transportation systems (ITS) has attracted a lot of interests for decrease the number of accidents at intersection using wireless data communication because, VANET can't estimate when nodes in the system have dynamic characteristic and special demand for low delay. 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)

The VANET provides a more effective way for vehicle to vehicle communication, vehicle to road side communication, sharing of information within each other, etc. For the maximum utilization of the VANET abilities, an efficient accident prediction scheme must be designed according to the requirement of the system to avoid the accident. The ingenuity must be able to provide more efficiency when implemented in VANET providing more safety and lesser complication in communication and possibilities of collision at intersection.

The paper includes with capabilities of evaluating probability of two colliding vehicles at the intersection using 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 Intersection. Depending upon the information stored and comparing this value with the threshold, the criticality of situation is calculated.

II. RELATED WORK

A communications perspective, we investigate the possibilities of safety applications using simple beaconing. In the vehicular networking community, approaches simple beaconing in terms of channel load or information dissemination range have been proposed. DV-Cast [9] points at mitigating the broadcast storm problem by rebroadcasting first from vehicles with largest distance from the original sender. Adaptive Traffic Beacon (ATB) [16] continuously adapts to the available channel capacity by modifying the beaconing interval.

A detailed study on communication requirements for crash avoidance applications has been published in [13]. The authors changed collision-free vehicle traces by artificially injecting collisions with constant velocity to evaluate their protocol in terms of crash mitigation possibilities. However, simplifying assumptions such as idealistic radio signal propagation and not considering low-speed collisions (< 7 m/s) limit the contribution for intersection safety applications.

Author Tang and Yip. investigated timings for collision avoidance systems [10] assuming DSRC transmission delays of 25ms and 300ms in normal and poorer conditions, respectively. They introduced the time to avoid collision metric, which represents the time from detecting a potential collision to the point of barely avoiding a collision and concentrated on the events (when to warn a driver early and latest, reaction of driver, and different deceleration rates) within this time interval.

[12] have been published the results and implications of real-world traces of driver braking behavior during intersection. This work shows that detecting real warning situations is not trivial, because avoiding false positives is essential for the success of ICWS.

Networking conditions, scenarios, and their implications are analyzed in [4], where the authors broadly discuss the requirements from the communication point of view of ICWS. Conceptually, the next step towards safety message exchange at intersections is the use of adequate relays. Eckhoff et al. investigated the use of parked vehicles in such scenarios [8].

In [7] author proposed a vehicle trajectory collision warning system based on Vehicle Infrastructure Integration system in order to improve the traffic safety. V2V wire- less 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 [2] 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 in- formation 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 [1], 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.

Our approach uses probabilistic model for trajectories to present all possible driver behavior and to find the collision probability. We use the obtained probability result to evaluate communication perspective of ICWSs and it gives the power for enhancing future communication procedure for intersection safety application.

III. INTERSECTION COLLISION PROBABILITY

Our aim is to calculate the probability of a possible collision whenever we have information about two potentially colliding vehicles available, i.e., every time a car receives a beacon message(which includes position information speed, heading, etc., of the sender). In our case, the needed information for two approaching vehicles A and B

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consists of the distances from their trajectories' intersection d_A and d_B and the speeds v_A and v_B, as well as the maximum acceleration α_{max} and the maximum deceleration(in terms of a minimum, negative acceleration)α_{min}. Notably, α_{min} and α_{max} are not necessarily the same for vehicles A and B but depend on each vehicle.

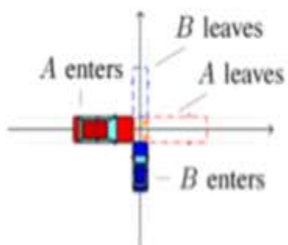
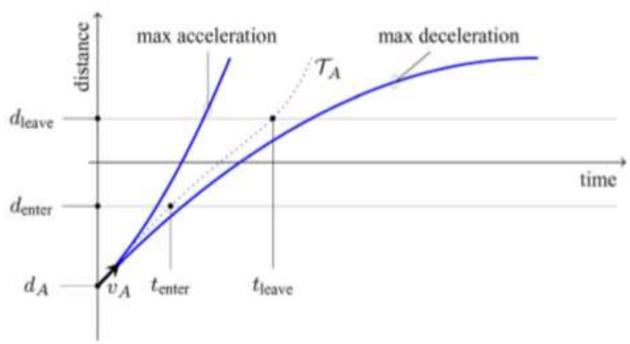


Fig. 1 Coordinate space for vehicle A and B for X-intersection

For defining distances d_A and d_B, the intersection is modeled as a simple coordinate space, where the axes are defined by the future driving path of the vehicles(Fig. 1). The axes' origins are at the center of where the vehicles' trajectories intersect. In the following, we concentrate on the X-intersection shown in Fig. 1

A. Trajectories

To define the intersection collision probability, we first need to mathematically model all possible driver behaviors of a single vehicle.



Fig, 2 Sample trajectory of vehicle A dependent on its distance d_A and speed v_A. Distances d_{enter} and d_{leave}, and times t_{enter} and t_{leave} are shown for an orthogonal X-intersection.

Depending on the current distance d_A and speed v_A of vehicle A, an unlimited number of future trajectories T_A (i.e., different intersection approaches) are possible. With current time being t_0, a trajectory is a feasible function of time that describes the vehicle's distance from the intersection center respecting the initial conditions and acceleration limits, i.e.,

$$T_A(t_0)=d_A \; \dot{T}_A(t_0)=v_A, \qquad \alpha_{min} \leq T_A(t) \leq \alpha_{max}. \qquad (1)$$

Given the current distance d_A and speed v_A of vehicle A, we call the measurable set of all possible future trajectories $\mathcal{T}_A = \bigcup T_A$. This set is limited by the maximum acceleration and α_{max} maximum deceleration α_{min}, as shown in Fig. 2.

To determine whether a collision happens for two trajectories $T_A \in \mathcal{T}_A$ and $T_B \in \mathcal{T}_B$, we define the function $coll(T_A,T_B)$ as

$$coll(T_A,T_B)=\begin{cases}1, & \text{if there is a collision}\\ 0, & \text{otherwise}\end{cases}$$

where we define a collision as occuring if the bounding boxes of the vehicles are overlapping at some point in time during the intersection approach.

B. Definition of Collision Probability

If we integrate over all possible trajectories $\mathcal{T}A$ and $\mathcal{T}B$ of two approaching vehicles, we can define the probability ρ_C of a collision at an intersection as

$$\mathcal{P}_C = \int_{\mathbf{T}_B}\int_{\mathbf{T}_A} p(\mathcal{T}_A, \mathcal{T}_B)\, \text{coll}(\mathcal{T}_A, \mathcal{T}_B)\, d\mathcal{T}_A\, d\mathcal{T}_B.$$

The function $p(T_A,T_B)$ gives the probability that the trajectories TA and TB are chosen and hence provides the possibility of modeling different kinds of driver behavior. In particular, this general definition of the collision probability does not assume the two chosen trajectories to be independent of each other. Moreover, our calculated collision probability does not distinguish situations where a crash has happened already and a future crash is unavoidabl; p_C will in both situations be 100%. In the following, we continue with a simplified version of this general approach because, to evaluate communication strategies for ICWSs.

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C. General Assumptions

The formulation presented is very general and has high expressive power. However, without some additional assumptions, it is hardly tractable. Thus, we now introduce several simplifying assumptions that can be selectively relaxed when additional insight on a specific issue is needed. As a first simplification, in the following, we consider only orthogonal X-intersection crossings without turning maneuvers. In this case, a collision happens for two given trajectories if both vehicles are in the potential collision area, i.e., where the vehicles might hit/touch each other [shown in Fig. 1(a) as orange crosshatched area] at the same time. The size of the potential collision area depends only on the vehicles widths. Thus, the times tenter and tleave, i.e., when a vehicle enters and leaves the potential collision area of a given trajectory, respectively, can be calculated using the trajectory and the distances d_{enter} and d_{leave}. The relationship between a sample trajectory TA, the times t_{enter} and t_{leave}, and the distances d_{enter} and d_{leave} is shown in Fig. 2. As a second simplification, we assume that the probabilities for the two trajectories T_A and T_B are independent. Currently, the literature does not give insight into whether and to what degree two approaching vehicles might influence the behavior of each other (causing a driver to accelerate, decelerate, or swerve). Moreover, we are particularly interested in situations where the drivers are not aware of each other; hence, the probability of choosing a certain trajectory does not depend on the other one. Furthermore, we consider only trajectories with a constant acceleration between α_{mim} and α_{max}. Under this constraint, every trajectory T can be identified by a tuple (a, v, d), and we can define a new function coll(·,·) analogous to (2) but only depending on these values. Hence, we can calculate ρ_C by integrating over the interval α_{min} and α_{max} for both vehicles as follows:

$$\mathcal{P}_C = \int_{a_{\min}}^{a_{\max}} p(a_B) \int_{a_{\min}}^{a_{\max}} p(a_A)\, \mathrm{coll}\left(\begin{bmatrix} a_A \\ v_A \\ d_A \end{bmatrix}, \begin{bmatrix} a_B \\ v_B \\ d_B \end{bmatrix} \right) da_A\, da_B.$$

The behavior of drivers, i.e., how likely it is that a driver chooses a certain acceleration, can now be modeled by defining the distribution of accelerations. In the following, we present possible simple distributions to give an idea of their impact on collision probability.

D. Uniform Acceleration Probability Distribution

One simple example is a uniform distribution of all possible accelerations between amin and amax. We will use this distribution to demonstrate the applicability of the collision probability defined in (3). Probability p(a) can be then calculated as

$$p(a) = \begin{cases} \frac{1}{a_{\max} - a_{\min}}, & \text{if } a_{\min} \le a \le a_{\max} \\ 0, & \text{otherwise} \end{cases}$$

resulting in

$$\mathcal{P}_C = \frac{1}{(a_{\max} - a_{\min})^2} \int_{a_{\min}}^{a_{\max}} \int_{a_{\min}}^{a_{\max}} \mathrm{coll}\left(\begin{bmatrix} a_A \\ v_A \\ d_A \end{bmatrix}, \begin{bmatrix} a_B \\ v_B \\ d_B \end{bmatrix} \right) da_A\, da_B.$$

IV. SIMULATION ENVIRNOMENT

We conduct an immense simulation study to validate and evaluate the collision probability estimation. For this, we used version 3.0 of vehicular network simulator Veins, which bidirectionally couple road traffic simulator SUMO 0.21.0 and the network simulator OMNeT++ 4.5. It extends the MiXiM physical layer simulation framework and provides a rich set of simulation models for realistic simulation of IVC protocol and application. Modified SUMO version used for generating vehicles mobility and IVC was simulated using OMNeT++.

For simulation, a typical suburban x intersection was extracted from Open Street. The map extracted from Open Street Map 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.

To run the simulation, configuration file of SUMO is needed which includes all the name of file such as net.xml and route.xml. As in figure 3 the road network is imported in SUMO simulator from Open Street Map. The vehicles are moving towards intersection

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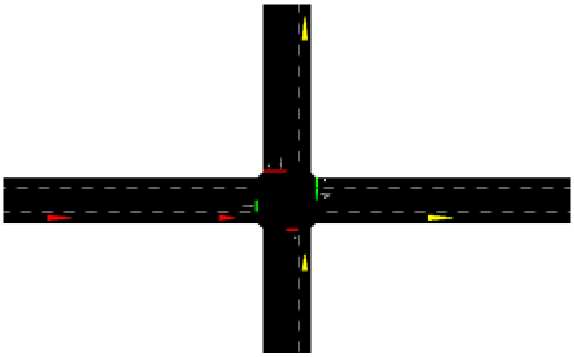

Fig. 3: Road Network in SUMO

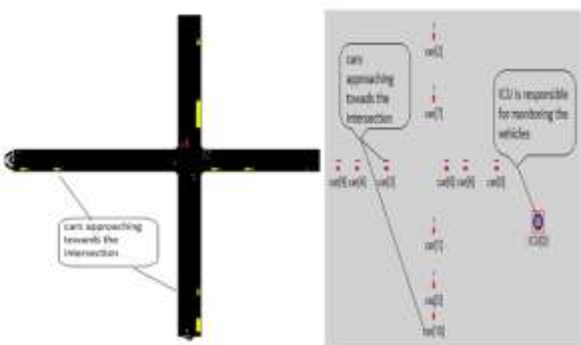

Fig. 4: SUMO and OMNet++ simulator running in parallel

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.

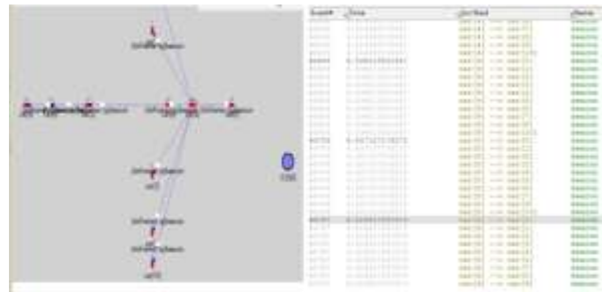

Fig. 5: Vehicle –vehicle communication and vehicle to ICU communication

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

V. RESULT

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

The first group Crash is considered to have the inter-section 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.

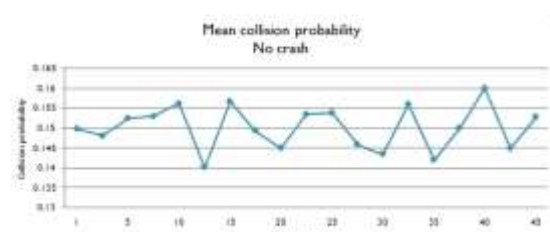

Fig. 6: Mean estimated collision probability for No Crash

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Above graph gives us the collision probability for the respective distance from point of intersection for no 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 0.14-0.16

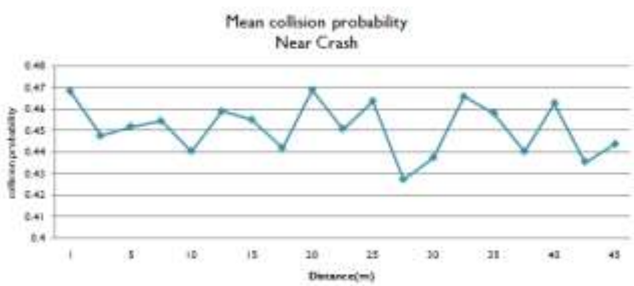

Fig. 7: Mean estimated collision probability for Near crash

It is apparent from the above 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.

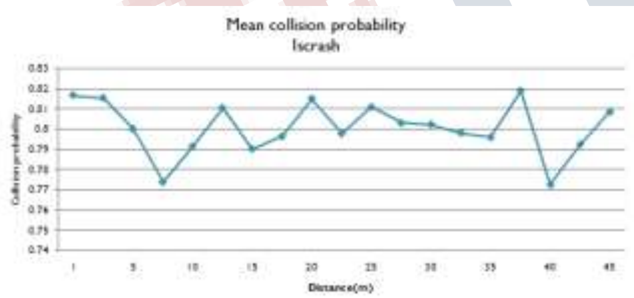

Fig. 8: Mean estimated collision probability for is carsh

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.

VII. COCLUSION

In this paper we were able to provide collision probability estimation which gives the judgment of criticality of two approaching vehicles at intersection based on exchanged of beacons message. SUMO, OMNET++ and VEINS provides a good environment of VANET simulations. In this system based on ICU and IVC. 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

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