

Prevention of Accident near Junction Area Using Smart Traffic Light Scheduling

Hamayoun Shahwani*, Muhammad Umar Chaudhry**, Jawad Yousaf[†], and Nokhaiz Tariz Khan^{††}

*Department of Telecommunication, Faculty of Information and Communication Technology, BUITEMS, Quetta, Pakistan

**Department of Electrical and Computer Engineering, Sungkyunkwan University, Suwon, South Korea

[†]Department of Electrical and Computer Engineering, Abu Dhabi, United Arab Emirates

^{††}Riphah School of Business & Management, Riphah International University, Lahore, Pakistan

hamayoun.yousaf@buitms.edu.pk, umarch@skku.edu, jawad.yousaf@adu.ac.ae, nokhaiz.tariq@riphah.edu.pk

Abstract— Traffic accidents mostly at junctions are intensifying as the traffic in urban areas is increasing. Due to a huge number of accidents at junctions, there is an immense need of a method to control or minimize the accidents around the junction areas. This paper presents a method of smart traffic signaling that informs the vehicles to stop, accelerate or decelerate near the junction, to minimize the overall accident rate. The proposed method allows the traffic light controller to control the timing of traffic lights in the emergency situations and also to inform the vehicles about the same. The suggested algorithm shows a much better performance than the conventional traffic light control system.

Keywords— VANET, V2V, V2I, I2V, traffic light controller

I. INTRODUCTION

The increasing number of vehicles on the road in urban cities have increased the probability of accidents which usually occurred around the junction areas. Although traffic lights are playing an important role in controlling the traffic flow but still the rate of occurring accidents on roads and particularly around junction areas are increasing due to the increase in the on-road vehicles in the metropolitan cities. These accidents are caused by human errors such as perceptual error, response error, distraction error, and so on [1].

Vehicular Adhoc Networks (VANET) has been introduced to overcome traffic related issues such as congestion, traffic safety, fuel consumption and provide infotainment services to the drivers and passengers. IEEE has standardized Dedicated Short Range Communication (DSRC) for VANET communication [2].

VANET is categorized in three types such as vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I) and infrastructure-to-vehicle (I2V). Vehicle in VANET are classified in 5 levels by the national highway safety administration (NHTSA) [3].

- Manual driving vehicle i.e., without automation are considered as level ‘0’.
- Limited automation vehicles are considered as level ‘1’ and ‘2’.
- Fully automated but offering limited safety environment are considered as level ‘3’.

- Fully automated vehicles with all safety features are considered as level ‘4’.

One of the main element to control the road accident is the traffic signal light control at the junctions [4]. Traffic lights are used as visual indication to control traffic flow at junctions. Green interval is the time of the green traffic light signal that indicates the moving direction of the vehicles in the specified direction, and usually its timing is between 50 to 100 seconds. Yellow interval is the time of yellow traffic light signal that indicates that the red traffic signal is about to appear and it is a sort of warning signal with usual timing of 2 to 10 seconds. Red interval is the time of red traffic light signal that directs the vehicles to stop and wait for the green light to appear, usually its timing is between 50 to 100 seconds.

Roxanne Hawi *et al.* [5] presented a smart traffic light system using sensor networks and fuzzy logics. Sensor network is supposed to gather real time traffic data and then aggregated data is sent to the fuzzy logic controller having two inputs i.e., traffic quantity and waiting time. Based on the inputs the fuzzy logic controller gives priority degree (PD) output. The lane with highest PD value is assigned green light first and then the next, and so on.

Anilloy Frank *et al.* [6] presented a traffic congestion control mechanism using image processing. Based on the real time image the vehicles are directed towards the junction to reduce the congestion in the particular area. Authors in [6] also presents a traffic congestion control system using real time vehicle density with the help of canny edge detection. Mozan Li *et al.* [7] provide a study on the yellow light dilemma and its factors. Yellow light dilemma is an area near the junction where vehicles neither can stop nor can proceed safely through the junction. The reported studies [6, 7] focus on the traffic congestion control by using smart traffic light signaling.

In this paper, we propose a smart traffic light control system that can prevent accidents at the junctions. As the vehicle proceed towards the junction, the traffic light will inform the vehicle either it can cross the junction in the allowable time or not.

The rest of the paper is organized as follows, Section II describes the proposed scheme. The performance evaluation

of the proposed procedures is discussed in Section III. Section IV includes the conclusion and future work.

II. PROPOSED SCHEME

Vehicles moving towards the junction can enter the junction instead of stopping on the red signal light because of the yellow light dilemma. It means that a driver may think of crossing the junction while the yellow light appears but he cannot make it in time and subsequently the red light appears. In Fig. 1 we can see that vehicle 1 in edge1 is moving towards the junction and another vehicle 2 from edge 2 is also moving towards the same junction. Due to yellow light dilemma they collide on the junction. To prevent such accidents we propose a smart traffic signal light control mechanism. Traffic light sends warning message to the vehicles that cannot cross the road before the appearance of the red light. If the vehicle decelerates its speed then the traffic light timing will be on regular schedule. If the vehicle proceeds in same speed towards the junction then the traffic light controller reschedules its timing by increasing the timing of yellow light a few more seconds to let the vehicle proceed safely. This will ultimately prevent accidents in junctions. The time at which the vehicle can cross the junction is given as follows:

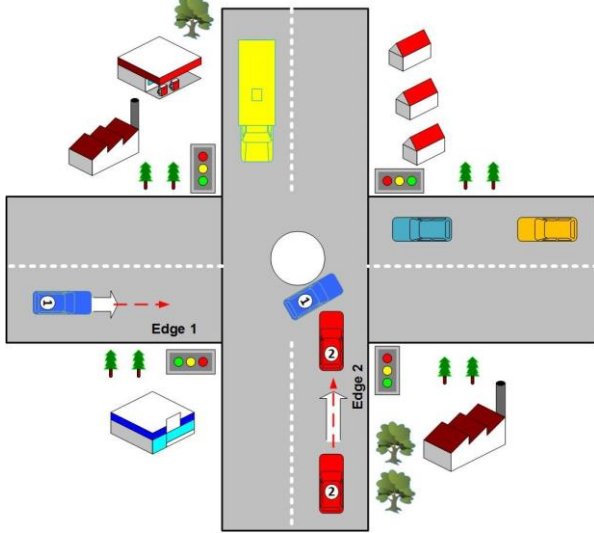


Figure 1. A typical urban city traffic scenario presenting accident near junction.

$$T_{Go} = t_G + t_Y \quad (1)$$

Where T_{Go} is the time by which vehicle can cross the junction, t_G is the time of green traffic light timing and t_Y represents the yellow traffic light timing. Vehicle approaching time and junction cross time can be calculated as follows:

$$T_V = \frac{d_V}{S_V} \quad (2)$$

Where T_V is the vehicle traveling time, d_V is the distance from the junction and S_V is the speed of the vehicle. The time a vehicle takes to cross the junction is given as follows:

$$T_j = \frac{l_j}{S_V} \quad (3)$$

In (3), T_j represents the vehicle traveling time to cross the junction, l_j is the length of the junction and S_V corresponds the speed of the vehicle.

Algorithm 1. Traffic light Scheduling

if $T_{Allow} < t_V + t_j$ **then**

 Inform the vehicle to stop as it cannot pass the junction or inform it to accelerate to pass.

if $S_{Vt} = S_{Vt+1}$ **then**

$T_{Go} = t_G + t_Y + 2\{(t_V + t_j) - (t_G + t_Y)\}$ for edge 1

 Adding extra time to edge 1 to let vehicle proceed.

$T_{Stop} = t_R + 2\{(t_V + t_j) - (t_G + t_Y)\}$ for edge 2

 Stopping vehicles at edge 2 for same period of time.

end if

else

 Proceed to go

end if

Algorithm.1 demonstrates the explanation of suggested scheme. It first checks vehicle time (T_V) to reach the junction combined with the time that vehicle takes to cross the junction i.e. T_j which should be less than the allowable time to cross the junction. In this case it can easily cross the junction without any collision. But if it is not so, then the traffic light has to inform the vehicle to decelerate its speed and stop before the junction. If the speed of vehicle remains same then the traffic lights are rescheduled to let this vehicle to pass the junction.

III. PERFORMANCE EVALUATION

In this section, we evaluate the performance of our proposed smart traffic light signalling to prevent accidents near junction areas. Our performance shows that the chances of accident are considerably minimized with intimation prior to the danger. This intimation helps the drivers to react with in time to prevent accidents. Simulation is done in MATLAB and simulation parameters are given in Table 1, where we have different values for two different cases. Case 1 is for checking the chances of accident with respect to speed where case 2 represents the checking of the chances of accident with respect to green traffic light signal. Figure 2 shows the chances of accident with respect to speed of vehicle, as the speed of vehicle increases the chances of collision at the junction increases. In this case we put the traffic light timing constant and changed the speed of vehicle to check the performance. We can see the difference of with prior intimation and without prior intimation. Figure 3 depicts the chances of accident with respect to green traffic light timing, as the green light timing is increased the chances of collision increases because the

vehicle get closer to the junction and it cannot get enough time for reaction.

TABLE 1. SIMULATION PARAMETERS

No	Parameter	Value
1	Vehicle speed for case 1	50 (km/h)
2	Traffic green light timing for case 1	0, 5, 10, 15, 20 (sec)
3	Vehicle speed for case 2	10, 15, 20, 25, 30 (km/h)
4	Traffic green light timing for case 2	40 (sec)
5	Traffic yellow light timing	10 (sec)
6	Drivers reaction time	10 (sec)
7	Distance of vehicle from junction	500 (m)
8	Junction length	80 (m)

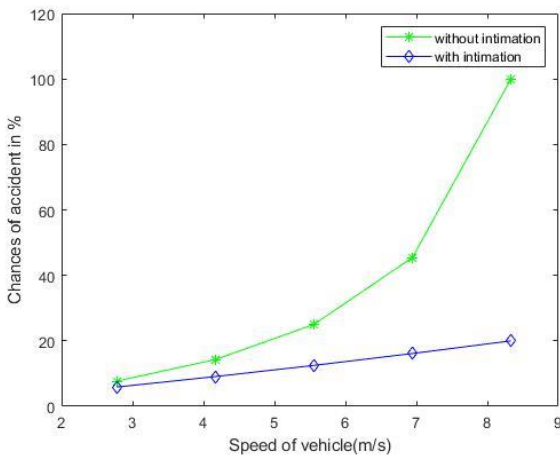


Figure 2. Chances of accident near junction area with respect to speed of vehicle.

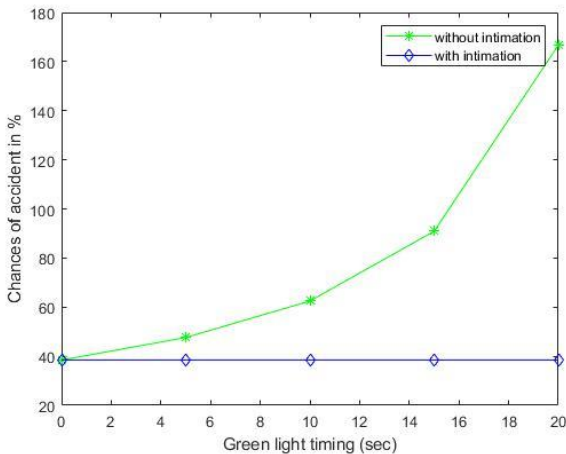


Figure 3. Chances of accident near junction area with respect to traffic light timing.

IV. CONCLUSION

This study proposed a method of smart traffic signaling that informs the vehicles to stop, accelerate or decelerate near the junction, aiming to reduce the rate of accidents. The proposed method allows the traffic light controller to control the timing of traffic lights in the emergency situations and also to inform the vehicles about the same. Vehicle are informed by the traffic lights that either within the current speed they can cross the junction before the red light appears or not, which is a better approach to prevent accidents near junction areas. We have shown through presented results that on-time intimation to the drivers help in preventing the accidents. For future work we will try to implement the same scenario in realistic simulator such as OMNET, SUMO and VEINS.

REFERENCES

- [1] Dahlia Sam, V. Cyril Raj, and T. Esther Evangelin, "A vehicle control system using a time synchronized hybrid vanet to reduce road accidents caused by human error," *In: Veh.Communication*, vol. 6, pp. 17-28, 2016.
- [2] Y. L. Morgan, "Notes on DSRC & WAVE Standards Suite: Its Architecture, Design, and Characteristics," *In IEEE Communications Surveys & Tutorials*, vol. 12, no. 4, pp. 504-518, Oct. 2010.
- [3] National highway traffic safety administration, preliminary statement of policy concerning automated vehicles. 2013.
- [4] Kinderytė-Poškienė J., & Sokolovskij, E., "Traffic control elements influence on accidents, mobility and the environment," *In Transport*, vol. 23, no.1, pp. 55-58, 2008.
- [5] Roxanne Hawi, George Okeyo, Michael Kimwele, "Smart traffic light control using fuzzy logic and wireless sensor network," *In IEEE Computing Conference*, pp. 450-460, 2017
- [6] Anilloy, F, Yasser. S. K. Al. A, Amer. Z, "IoT based Smart Traffic density Control using Image Processing," *In 4th MEC International Conference on Big Data and Smart City (ICBDSC)*, 2019.
- [7] J. Breckling, Ed., *The Analysis of Directional Time Series: Applications to Wind Speed and Direction*, ser. Lecture Notes in Statistics. Berlin, Germany: Springer, 1989, vol. 61.



Hamayoun Shahwani received his BS degree from Balochistan University of Information Technology, Engineering and Management Sciences in 2010. He then received his Ph.D. degree in Electronic and Electrical Engineering from College of Information and Communication Engineering, Sungkyunkwan University, Republic of Korea in 2019. He is currently serving as Assistant Professor in Balochistan University of Information Technology, Engineering and Management Sciences. His research interests include machine-to-machine communication, 5G communication systems, and vehicular ad hoc networks.



Muhammad Umar Chaudhry received his B.S. in computer engineering from Bahauddin Zakariya University, Multan, Pakistan, in 2009. From 2010 to 2014, he served as an Instructor at Virtual University of Pakistan, Lahore, Pakistan. Currently, he is pursuing the Ph.D. degree at Sungkyunkwan University, Suwon, Korea. His research interests include recommender systems, feature selection, and machine learning.



Jawad Yousaf received the PhD. and MS degrees in Electronics and Electrical Engineering from Sungkyunkwan University, Suwon, Korea, in 2019 and 2016 respectively. He is currently working as Assistant Professor in Electrical and Computer Engineering department of Abu Dhabi University, United Arab Emirates. Lastly, he worked as Brain of Korea (BK)-Postdoctoral Fellow in the EMC laboratory of Sungkyunkwan University, Suwon, Korea from March 2019 to July 2019. Previously,

he worked as the senior RF researcher in the Pakistan Space and Upper Atmosphere Research Commission (SUPARCO: National Space Agency of Pakistan) from 2009 to 2013. His research interests include applications of Artificial intelligence in electromagnetics, ESD analysis, Reverberation chamber, CP antenna designing and modeling, Chipless RFID tags and EMI/EMC analysis and measurements of the systems for space and commercial environment.



Nokhaiz Tariq Khan is Assistant Professor at Riphah School of Business and Management. He received his BS degree in Electronics Engineering from Islamia University of Bahawalpur. He then received his PhD degree in Industrial Engineering from Sungkyunkwan University, Suwon, South Korea. His research interest are Demand forecasting, simulation and modeling, Supply Chain Management, Lean and Green practices