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http://dx.doi.org/10.5339/qfarc.2016.ICTPP2612

Novel Vehicle Awareness Measure for Secure Road Traffic Safety Applications

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Future intelligent transport systems (ITS) are envisaged to offer drivers with a safer and comfortable driving experience by using wireless data exchange between vehicles. A number of applications could be realized with the increased vehicle vision and awareness provided by this technology known as Vehicular Ad hoc Network (VANETs). These applications include cooperative awareness, warning notification, safe lane change and intersection crossing, intelligent route selection, traffic management, parking selection, multi-player games and internet browsing.

The success of VANETs and its proposed applications depend on secure and reliable message transmission between the vehicles. Every vehicle broadcasts periodic safety messages to the neighborhood traffic to inform about its presence. This safety message contains vehicle's mobility information including its location, speed, direction, heading etc. Based on these safety messages, vehicles develop a local dynamic map (LDM) that provides them a complete description of the surrounding traffic. Using LDM, vehicles could look beyond line of sight and make safe and intelligent driving decisions.

An increased level of vehicle safety awareness is the primary goal for road safety applications. An accurate measure of this awareness is critical to evaluate impact of different parameters such as security, vehicle density etc. on vehicle safety and application quality of service. A precise and correct metric for safety awareness of vehicles should take into account the knowledge of vehicle's surrounding and accuracy of received information in CAM and LDM. Existing metrics in the literature utilize quantitative measure of awareness such as packet delivery ratio and do not consider accuracy and fidelity of received information in the LDM. Due to GPS error and outdated information in the LDM, vehicles could have a reduced level of awareness resulting in dissemination of false positives and false negatives that could badly impact road safety applications.

In this paper, we propose two novel metrics for evaluating vehicle safety awareness. These metrics start by using our proposed vehicle heading based filtering mechanism to only consider the critical neighbors in the surrounding (i.e., the ones that are moving towards a vehicle and have a chance to collide with it) for calculating awareness. The first

Cite this article as: Javed MA, Hamida EB. (2016). Novel Vehicle Awareness Measure for Secure Road Traffic Safety Applications. Qatar Foundation Annual Research Conference Proceedings 2016: ICTPP2612 http://dx.doi.org/10.5339/qfarc.2016.ICTPP2612.

metric known as Normalized Error based Safety Awareness Level (SAL) calculates awareness by measuring the number of neighbors a vehicle has successfully discovered in its LDM and a normalized distance error that is calculated based on actual position of each neighbor and its position information that is available in the LDM. By considering the position error in the information contained in the LDM, vehicles accurately measure their awareness levels.

To further improve the above safety awareness metric, we propose a weighted Normalized Error based Safety Awareness Level (wSAL) metric that assigns higher weight to error coming from neighbor vehicles that are nearby using a sigmoid function. Since position error of a closer neighbor is more critical in safety applications, vehicle awareness level could be more accurately measured by allocating a higher importance to them.

We developed a simulation model using NS-3 network simulator and SUMO traffic simulator to generate realistic road traffic scenario at different vehicle densities. Simulation results verify that the existing metrics provide optimistic results for vehicle awareness and our proposed metrics improve the measure of awareness. This leads to a better performance evaluation of safety applications.