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IMPROVING ROAD SAFETY FOR PEDESTRIANS IN BLACK SPOTS USING A HYBRID VANET OF VEHICULAR SENSORS AND PEDESTRIAN BODY UNIT

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ABSTRACT

With the rapid explosion of population, usage of motor vehicle is also increasing. This has been causing a serious issue in road safety for the past few decades. Road pedestrian injuries and death rate is also rising day by day. The research on traffic accidents shows a clear concentration of crashes happening in Black Spots. Accident black spots include steep slopes, a hidden junction, sharp corners in straight road, curvy roads concealed warning signs or situations where the oncoming traffic is not visible. The histories of traffic accident in the recent years have established a dependency between the accident and the reaction time of the involved persons. This is mainly due to tensed reactions of the drivers or pedestrians that come spontaneously while facing a real time potentially dangerous scenario. In this paper we provide a solution by proposing a Hybrid VANET based driver alert system. An alert given to the drivers ahead of time gives a better chance for the driver's tore act in a way as to avoid accidents. The system is designed by integrating a pedestrian body unit along with the vehicular nodes in a VANET. The signals sent by the pedestrian body unit are received by the vehicular nodes in the VANET and are given as input to the alert system. This alert wills notify the drivers about surrounding pedestrians, which in turn gives him more reaction time. The system was simulated and a laboratory demonstration was also done. It all proved that the system was able to reduce the chances of accident drastically with the alert system.

Keywords: vehicular Ad Hoc networks (VANETs), hybrid VANET, pedestrian safety system, road safety, pedestrian body unit, GPS.

1. INTRODUCTION

In today's world there has been increasing number of vehicles on the road than ever before. Driving is becoming a requisite part of any normal man's life. The frequency of accidents has been increasing due to the high usage of vehicles. The development of wireless technologies has led to the design of communication systems with the vehicles as participants in communication. The evolution of this vehicular technology has motivated many vehicle manufacturers, government organizations and research institutions to focus their efforts to give a solution to improving road safety. The type of network that has been created is called the Vehicular Ad Hoc Network (VANET). This will make the possible communication between vehicles themselves and between the vehicles and infrastructure. This is an assuring technology that proves to be helpful in accident prevention, pedestrian safety and improving overall highway safety. Researchers have been continuously working on using VANETs for applications like driving safety, lane changing, safe highway entry, intelligent speed control, and exiting, timely warning during hard braking and accidents etc. [16].

2. LITERATURE REVIEW

2.1 Motivation

As the number of vehicles is increasing, accidents occurring due to vehicles are also growing regularly. As a result, road traffic death has become the 5th leading cause of death in the environment. According to the global status report on Road Safety in 2013, death rate has increased to 1.24 million per annum. Among these pedestrian accidents, highway hit and run death count comprise about 22 % of the total number. These kinds of road users include handicapped people, people on medication, careless kids, drunken persons, old age people, distracted people chatting with fellow passengers or over the cell phone etc. A high concentration of pedestrian deaths is seen in low and medium income countries that are becoming motorized.

Pedestrian death toll in the United States has increased by 15% in the past decade whereas the other causes of motor vehicle deaths have declined by 3%. Pedestrian deaths have been mainly seen in urban areas occurring frequently during late nights, early evenings, rainy days, curvy roads, foggy times, and other low visibility situations. Unexpected crashes typically have involved people who have the habit of alcohol consumption, handicapped people, kids and people older than 70 years. Some of the attainable explanations for the increase in pedestrian deaths in the recent decades include the encouragement of regular walking by doctors for healthy living and environmental benefits, the effects of the economic bankruptcy coupled with the raising of fuel costs that resulted in many walkers, favourable weather conditions, increase in the number of drivers on the road and the growth in the number of vulnerable population like senior citizens and immigrants. There have been many measures taken by the Governments and other social organizations to create safe walking conditions for

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pedestrians like Walking Plaza but nothing has come out very successful so far.

2.2 Related work

To reduce the accidents, a system named pre-crashing detection system using laser and radar sensors was proposed in [14]. These authors use sensing technologies to help detect the hindrances on the road. Another system named mobileyeC2-270 collision warning system, which cautioned drivers of dangerously close cars, alerts them when riding out of their lane and includes a Pedestrian Collision Warning component. This operation enlarges the communication but the computation costs still remain high. In [2], the authors have proposed a hybrid VANET system that combines the advantages of both the VANET as well as the WSN (wireless sensor network) which is a low cost reliable solution. Wireless roadside sensors are integrated with the VANET to constantly detect all possible events in the road and communicate to the vehicles. The system uses a long-range passive infrared (PIR) sensor with 90-100° wide detection cone, 20-30 feet detection range for human presence and 50-150 feet detection range for vehicles depending on the size. The sensor can be directly plugged in to the external connector of IEEE 802.15.4 / Zigbee compatible TelosB motes. The main disadvantage with the above system is that it is very much possible that the presence of a human may go unnoticed by the sensor. This could be leading to an accident which involves the pedestrian. To overcome this problem, we propose a solution to integrate a human body unit with the VANET. This will ensure that the presence of any humans will never go undetected. This system is done with the help of a Global Positioning System (GPS) and this will aid in controlling the pedestrian accident rate to a greater extent.

3. SYSTEM MODEL

3.1 VANETS

A vehicular ad hoc network (VANET) uses cars as mobile nodes in a MANET to create a mobile network. A VANET turns every participating car into a wireless router or node, which connects and creates a network with a wide range allowing cars approximately 100 to 300 meters of each other .Once the cars fall out of the signal range and drop out of the network, a mobile network is created by the connection of other cars joined together. VANET is improving day by day and supports numerous applications and products to be used in vehicles. These products include remote keyless entry devices, laptops, personal digital assistants (PDAs) and mobile telephones. Some of the possible VANET applications include automated toll payment, finding the closest fuel station, broad range of safety and non-safety applications such as vehicle safety, traffic management, and enhanced navigation, restaurant or travel lodge and providing access to the internet.

A VANET is comprised of vehicular nodes as well as road side units (RSUs). RSUs are distributed in the highways in different places. It could be deployed at fixed intervals or placed in low traffic areas like hills, tunnels etc. Even though when the vehicles are not present in the road, these play an important role in keeping the network connected. There are three types of communication that prevails in VANETs. They are Vehicle-to-Vehicle (V2V), Vehicle-to-Roadside (V2R) and Vehicle-to-Infrastructure (V2I) communications as depicted in Figure-1. VANETs have some unique characteristics as compared to other networks. These include high mobility, hard delay constraints, minimum power constraints, rapidly changing topology and unpredictable network size. The movement of the vehicular nodes is attributed by prebuilt highways, roads and streets and width of the lane. So given the speed and the street map, the mobility of the vehicle can be modelled and the future position can be easily obtained.

3.2 Integrating pedestrian body unit with VANET

The concept of wireless body area network (WBAN) was first invented by Van Dam *et al*. in 2001 [4] which was followed by the interest of several researchers [5-7]. It is a Wireless Body Network formed by wireless sensors connected in the body. These body sensors are usually compact, consume less power and flexible. These sensors can generate various data that can be applied in the various applications such as gaming, sport, lifestyle, remote health monitoring, emergency situations, medical applications, defence, and consumer electronics [8]. These sensor data are transmitted through high power gateway and generate control signals.

In this work, the possibility of integrating the above mentioned wireless body network with the VANET to improve human safety was analysed. The proposed hybrid VANET system is represented in Figure-1. This integrated system could improve human detection by vehicles and thereby prevent pedestrian accidents. The system can alert the motorists under circumstances like: pedestrians walking in the middle of the road unexpectedly, drunken pedestrians, handicapped people with limited vision or slow mobility trying to cross the road, kids playing in the backyard accidently running into the road, old age, pedestrians walking in reduced visibility areas.

The system is designed in the following way. The VANET is comprised of Vehicle nodes and Road Side Units (RSUs). A body sensor attached to a human body could be designed in the way to transmit the pedestrians exact location information to the nearby RSU (Road Side Unit) or to the approaching vehicles through communication interfaces. This body sensor communicates with the RSU or the vehicular node in the neighbourhood area of the formed VANET. It will help alert drivers about the pedestrians before they approach the spot. Each vehicle node, RSU and body sensor communicates with each other using the WiFi (IEEE 802.11) communication interface.

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Figure-1. System model.

With the development of low cost wearable computers like smart coats, smart watches, Google glasses and Google specs [8, 18], this system is surely a expedient solution to reduce pedestrian deaths due to road accidents in the recent years. In this work, a GPS (global positioning system) was used as the wireless body sensor. GPS is now becoming part of everyone's life as in the form smart phones, tablets, laptops etc. The information from the GPS is traded in the structured format within the nearby vehicles and or RSUs in its communication range. These data is then transferred within the VANET [17]. The driver is warned by this alert message and can take appropriate measures to prevent forthcoming accidents, such as applying brakes, changing the lane or slowing down the vehicle. This communication is demonstrated in Figure-2.

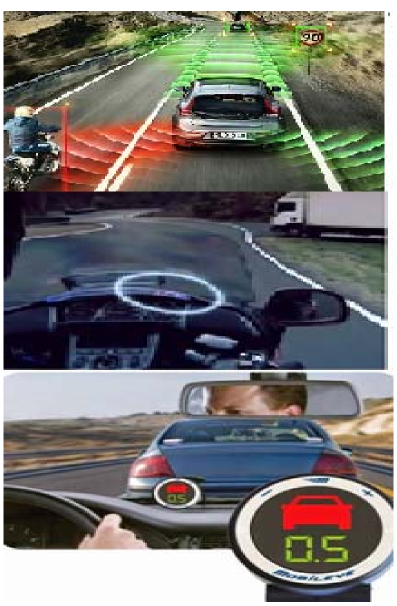

Figure-2. Alerting the vehicle.

4. EXPERIMENTS

4.1 Simulation results

For the simulation, a pedestrian crossing a multi-lane highway with no traffic controls was assumed. A large truck parked in the first lane conceals the pedestrian's view of the oncoming vehicles. Similar case occurs during severe snowfall when a pile of snow is deposited in the sidewalk and obscures the pedestrian's view. Suppose a vehicle comes in the second lane, it creates a Black Spot and has high chances of ending up in an accident. The scenario is illustrated in Figure-3.

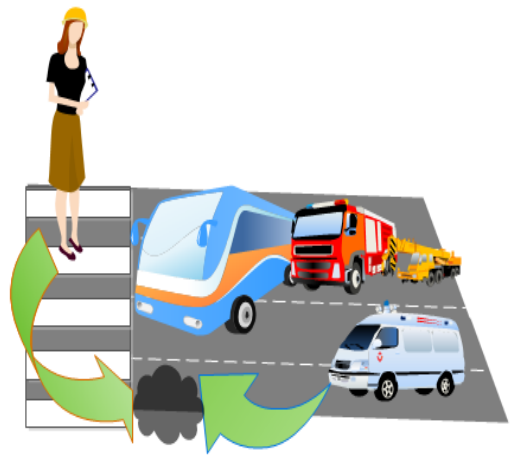

Figure-3. An example of a black spot.

GrooveNet simulator was used to simulate the proposed hybrid VANET system with body sensor. In the simulation model, the vehicles were assumed to be running in a 3-lane highway. The incoming traffic flow was considered as 3000 vehicles per hour i.e approximately 1000 v/h/l. The distance between the crosswalk and the obstacle in our setup was assumed to be 0.75 m. The other parameters that were fixed for the simulation are shown in Table-1.

Table-1. Simulation parameters.

Highway length	18900×20m
Number of sensor nodes	200
Distance between two sensors	80 m
Transmission range of sensor node	100 m
Transmission range of vehicle nodes	250 m
Average packet loss ratio	15%
Average vehicle speed	40 km/hr
Simulation time	60 min

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Research shows that the pedestrian reaction time is considered as 0.28±0.07 sec and the driver reaction time is considered as 0.75 sec. The brain reaction time includes the mental processing time and the body movement time. The mental processing time is the time to perceive a scenario and the body movement time is the time taken to react to the visual stimulus. In this case, the body movement time for the pedestrian is the time taken to stop or move backwards. For the driver, it is the time taken to lift the foot from the accelerator and apply the brakes. Study also shows that women react slower than the male counter parts. Similarly, drivers or pedestrians who are drunk, sick or tensed tend to react slower. If an alert message could be given in such a way that the driver has enough time to process the situation in his brain and react, then there is a high possibility that the driver will be able to prevent an accident. The driver's brain has the time to take the correct decision to the stimulus received as opposed to reactions taken in panic. This increases the chances of preventing accidents.

The proposed system was designed and the two different situations were analysed to define the possibility of accidents. The first time no alert was given and the driver reacts normally to the situation. When the oncoming vehicle speed is as low as 12 km/hr, it was seen that the pedestrians are in dangerous situation. On the other hand, when the drivers are alerted using the hybrid VANET system, the situation improves intensely. The pedestrians are in danger only when the vehicle speed is above 35 km/hr. The results are shown in Figure-4.

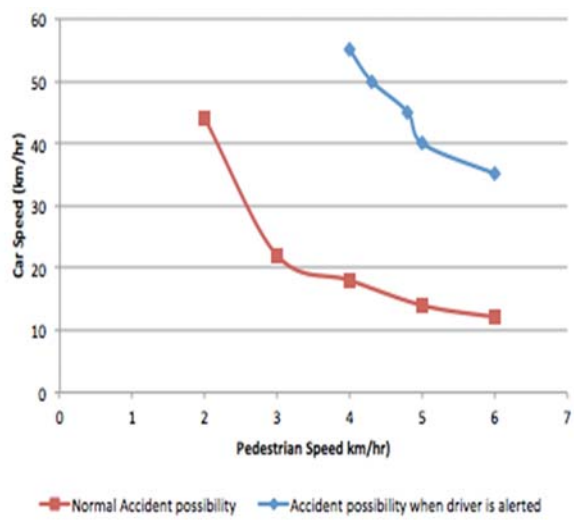

Figure-4. Reduced accident possibility with the hybrid VANET alert system.

4.2 Laboratory test

The hybrid VANET comprising of the vehicular node and the pedestrian node was set up in a laboratory. Three laptops were used to emulate the vehicles on the road. Three smart phones were used to emulate the pedestrians. A GPS application was installed in the laptops and the mobile phones. With this GPS (Global Positioning System), the position of the pedestrians and vehicles can be traced out. If the path of the both comes in the close proximity of each other, a warning message is displayed in the mobile and laptop. An android application was created for this "alert message" and installed in the mobile. On seeing this caution message, the driver as well as the pedestrian will get cautious. The sample result screenshots are shown in Figure-5, Figure-6 and Figure-7. Figure-5 shows the position of the vehicles and pedestrians with respect to each other. The next Figure-6 traces the path of movement of the vehicle and the pedestrian. When the vehicle and pedestrian come closer to each other a warning message is displayed which is shown in Figure-7.

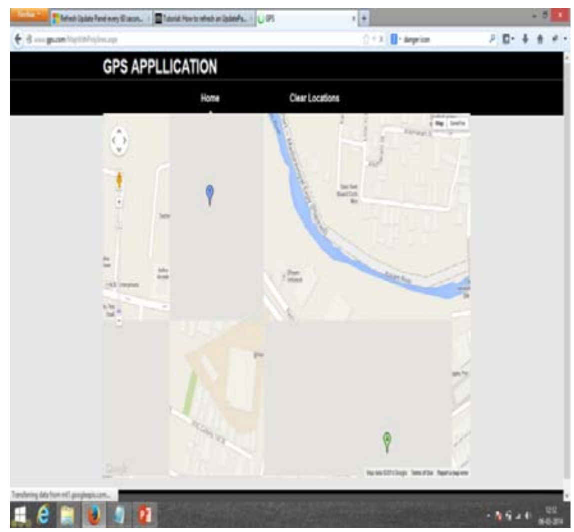

Figure-5. GPS position of pedestrian and vehicle.

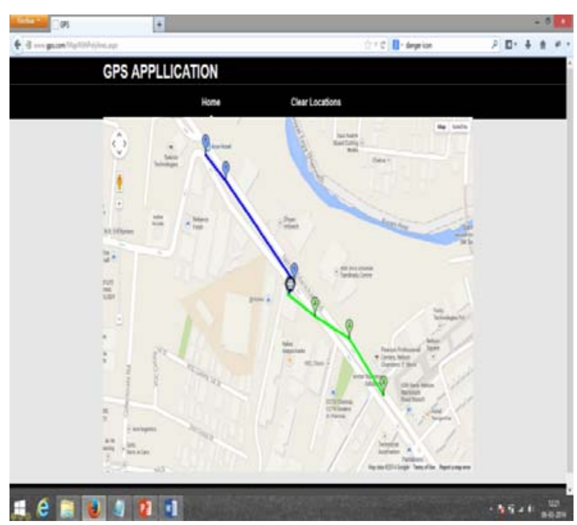

Figure-6. Tracing out the paths.

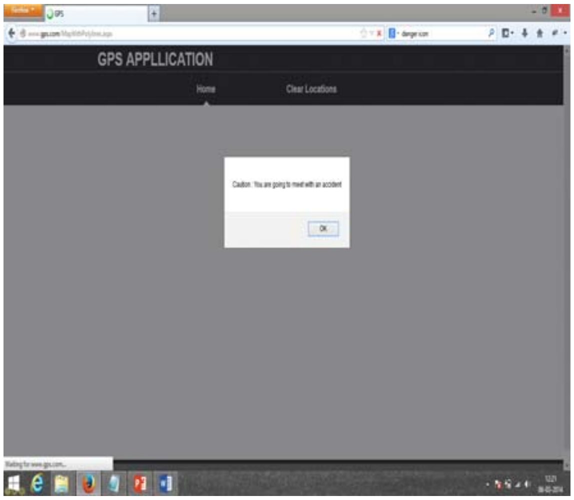

Figure-7. Warning message.

5. CONCLUSIONS

In this paper we have proposed a novel idea to design a Hybrid VANET system that integrates a body unit with the vehicular ad hoc network (VANET). The proposed system was simulated and the results prove that the road accidents can be reduced to a great extent. The laboratory demonstration was also done in order to emulate the real time applications. The system has given positive results. In future, this new system could be deployed to assure an extra level of safety to the lackadaisical pedestrians who might accidentally get hit by drivers. This system will reduce the overall death rate of the pedestrians on the road. With the development of low cost wearable computers in the recent years, this system is surely a feasible solution to reduce pedestrian deaths due to road accidents in the near future.

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