Intersection Collision Detection And Warning Protocol: Design Approach

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Abstract - In recent years, the number of vehicles has increased dramatically. This causes a high traffic density and makes new security features a crucial point in order to keep the traffic safe. Developing automotive collision warning and avoidance systems will be very effective for reducing fatalities, injuries and associated costs. In order to develop an automotive collision warning and avoidance system, it is necessary that the vehicles should be able to exchange their dynamic information such as speed, acceleration, direction, relative position, etc. This paper presents a collision detection and warning protocol in intersection traffic controller (ITC) to improve the intelligent transportation systems (ITS) using a wireless communication technology. Each vehicle communicates with the ITC in real time to let the ITC know about its current location. The ITC includes this information in its message and warn the driver about the condition of the vehicle and the signal to avoid collision.

Keywords: ITS, ITC, IVC, CWS

I. INTRODUCTION

Recently much attention has been devoted to the research in the field of IVC (Inter-Vehicular Communications).

Indeed, the advances in wireless technologies are making it possible to deploy new services: some of the most interesting ones aim at increasing safety over highways and streets by delivering warning messages, or through cooperative or assisted drive.

In order to reduce the number of traffic accidents and improve the safety and efficiency of traffic, the research on Intelligent Transportation System (ITS) has been developed for many years in many countries[1]-[2]. ITS gives benefits which are improvement of safety and reduction of driver stress by giving drivers useful information and control. Many researchers have taken interest in this area and proposed a number of crash avoidance systems [3]-[5]. With recent advance in sensing, computing, and communication technologies, new driving assistance systems such as night vision and collision warning systems (CWS) have been designed, tested, and deployed. While night vision systems simply provide visual assistance to drivers in dark environment, collision warning and avoidance systems generally exhibit some intelligence. Despite the fact that intersection collision accounts for almost 30% of all crashes, intersection collision avoidance systems received less attention than the forward collision avoidance systems. The reason, besides the fact that the intersection collision problem is more complicated than rear-end crash, is the limitation of the radar technology, the most widely used object sensing method in vehicle collision avoidance systems.

The present technologies that are being investigated to avoid intersection collisions are differential global positioning systems (DGPS), electronic compasses, roadside sensors, etc. [6,7]. There are several disadvantages of these technologies. For example, the GPS signals have some errors and in some areas, especially in downtown areas with very tall buildings, the signals may not be detected. The roadside sensors may not detect some vehicles if there are multiple lanes on the road.

It becomes imperative that the vehicles exchange dynamic information such as speed, acceleration, position and direction in real time. Wireless communications do not require line-of-sight[8]. Thus, using wireless communication technologies, the vehicles can inform each other about how far they are from the intersection and receive the dynamic information of the signal lights and the status of the intersection. The goal of the intersection collision detection and warning protocol is to warn the driver about the condition of the vehicle and the signal to avoid the collision [9].

Also, FDMA (Frequency Division Multiple Access), TDMA (Time Division Multiple Access) and CDMA (Code Division Multiple Access) are the well known multiplexing techniques used in wireless communication systems. While working with the wireless systems using these techniques various problems encountered are (i) multipath fading (ii) time dispersion which lead to intersymbol interference (ISI) (iii) lower bit rate capacity (iv) requirement of larger transmit power for high bit rate and (v) less spectral efficiency. In a typical terrestrial broadcasting, the transmitted signal arrives at the receiver using various paths of different lengths. Since multiple versions of the signal interfere with each other, it becomes difficult to extract the original information.
The use of FFT technique to implement modulation and demodulation functions makes it computationally more efficient.

II. BACKGROUND

The main purpose of the Next generation ITS is the safe driving, which is represented by the developments of Advanced Vehicle Control and Safety System (AVCSS) [10].

The goal of the AVCSS is to improve the safety and convenience of driving, optimize energy consumption by having smooth traffic flow and increase the efficiency of transport industry. Other applications of ITS such as Advanced Traffic Management Systems (ATMS) [11] and Advanced Traveler Information Systems (ATIS) [12] are going to have new developments in the future. In order to design more efficient and safe transportation systems it is very important the design of efficient and safe inter-vehicle communication protocols.

Most IVC protocols use flooding as the simplest way to broadcast. Flooding performs relatively well for a limited small number of nodes, but the performance drops quickly as the number of nodes increases. As each node receives and broadcasts the message almost at the same time, this causes contentions and collisions, broadcast storms and high bandwidth consumption [13].

Recently, a number of research groups have proposed more efficient broadcasting techniques. Centralized broadcasting schemes are presented in [14]. Algorithms in [15] utilize neighborhood information to reduce redundant messages in a Mobile Ad Hoc Network. Schemes in [16] deal with disseminating data in sensor networks.

In this paper authors present the very simple and efficient protocol, which needs minimal neighborhood information. This protocol provides the information to warn the driver about the condition of the vehicle and the signal to avoid the collision.

III. METHODOLOGY

A. Intersection Collision Warning System

A wireless unit (ITC) installed at the intersection and wireless unit installed in the vehicle exchange the information about speed, lane no., road no. and the status of the signal at that particular intersection, if the red signal is ON then ITC send the message to the vehicle time left for turning yellow light to red on red to green, so that driver speed down or speed up the vehicle to avoid the collision at intersection.

B. Broadcasting Method

ITC continuously broadcast the message about the status of signal. When the vehicle comes in the range of the ITC it will receive the message and vehicle transmits the message including of road no., lane no., and speed of the vehicle.

After receiving message from vehicle ITC calculates the distance between Intersection and vehicle approaching and send it to the vehicle approaching towards the intersection along with lane no., road no. and status of signal. Vehicle matches the received data with their own data, if it is same then driver has to speed up or speed up the vehicle to avoid the accidents. If data received is not as identical with their own data then driver should ignore the received message.

C. Modulation Technique

The use of orthogonal frequency division multiplexing (OFDM) technique provides better solution for the problems created by multiplexing techniques like FDMA, CDMA, TDMA, etc. In an OFDM scheme, a large number of orthogonal, overlapping, narrow band sub-channels or subcarriers, transmitted in parallel, divide the available transmission bandwidth. OFDM technique distributes the data over a large number of carriers that are spaced apart at precise frequencies. This spacing provides the “orthogonality”, which prevents the demodulator from seeing frequencies other than their own frequency. The separation of the subcarriers is theoretically minimal such that there is a very compact spectral utilization. The benefits of OFDM are high spectral efficiency, resiliency of RF interference, and lower multi-path distortion. OFDM is a powerful modulation technique that is capable of high data rate and is able to eliminate ISI. The OFDM based wireless communication system design includes the design of OFDM transmitter, and OFDM receiver.

D. Adding a Guard Period to OFDM

One of the most important properties of OFDM transmissions is its high level of robustness against multipath delay spread. This is a result of the long symbol period used, which minimizes the inter-symbol interference.
The above figure shows the Structure of the OFDM symbol after adding GI, where ‘p’ is the length of the Guard period. Other variations of guard periods are possible. One possible variation is to have half the guard period a cyclic extension of the symbol, as above, the other half a zero amplitude signal. Using this method the symbols can be easily identified. This possibly allows for symbol timing to be recovered from the signal, simply by applying envelop detection. The disadvantage of using this guard period method is that the zero period does not give any multipath tolerance, thus the effective active guard period is halved in length.

E. OFDM Model Used

The OFDM system was modeled using MATLAB and is shown in following figure. A brief description of the model is provided below.

In this protocol design BPSK modulation scheme is used. The required spectrum is then converted back to its time domain signal using an Inverse Fourier Transform (IFFT). The Fast Fourier Transform (FFT) transforms a cyclic time domain signal into its equivalent frequency spectrum. Before this one of the most important properties of OFDM transmissions is the robustness against multipath delay spread. This is achieved by having a long symbol period, which minimizes the inter-symbol interference. The level of robustness can be increased even more by the addition of a guard period between transmitted symbols.

IV. SIMULATION

Following are the simulation results obtained.

Fig. 4. Pseudorandom signal input

Above Fig. 4, is pseudorandom input signal which is input through serial to parallel block of transmitter. This pseudorandom signal is generated by mathematical formula by considering binary sequence in a sequence of N-bits.

Fig. 5 Received OFDM signal
The data signal is transmitted by ITC to the vehicle, i.e. a message signal with signal activation data, pre-warning message and distance between the ITC and the vehicle approaching toward the intersection. Fig. 5. is received OFDM modulated frequency domain received data, which includes the data received that is pre-crash warning and the distance, send by the ITC to the vehicle. In this way data is transmitted and received from ITC to Vehicle and vice-versa.

In Fig. 6 we have shown two vehicles initially at position one. This graphical view is created in GUI of Matlab. In Fig. 6, GUI we have total nine signals has been shown. As the Vehicle A or Vehicle B moves from initial position to desired position this position is displayed on the display unit present in the vehicle. Aim is that whatever position each vehicle will acquire the same position will be automatically transferred to ITC and then ITC will give the corresponding position of that particular vehicle to other vehicles in his vicinity.

Fig. 7. shows the GUI in which vehicle A is at signal 3 and vehicle B is at signal 2. In this manner we have verified the various combinations by changing the position of the vehicles at different signal points. To our satisfaction we got 100% accurate results using OFDM modulation technique.

In above Fig. 8 shows Vehicle B is at position nine and Vehicle A is at position one. Assuming that both the vehicles are traveling in opposite direction and single lane road is considered then there is chances od collision if drivers proper attention is not available. In this scenario also we have worked and our simulation results gives appropriate messages to both the vehicles and collision situation can be avoided, like in simulation result we get the message “Slow down the speed” to avoid collision. The message may be voice message in that case so that driver will be alerted or if vehicle is fully autonomous in that case vehicle itself will take intelligent decision and automatically slows down.

Fig. 9. shows how the simulation result helps to avoid accident i.e. pre-crash warning messages can be given to both vehicles, if both vehicles are coming in opposite direction in a single lane road. Maximum accidents can be prevented if pre-crash warning is given even before one or two seconds. This protocol gives the pre-crash warning message in millisecond to both the vehicles within the safe distance. This is very helpful to prevent the accidents.
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Fig.9. Message from ITC to Vehicle

V. CONCLUSION

In this paper authors proposed the Intersection collision detection and warning protocol. Using this protocol accident at intersection can be efficiently avoided by providing pre-crash warning message to both the vehicles. Such type of protocols can be useful in zig-zag road conditions especially in the hilly regions. Also protocol can be useful in single lane road scenarios. Furthermore the protocol can be useful for many other applications by providing the visualisation section within it. There are still numerous challenges existing in the same protocol, which will be implemented in future work.

REFERENCES


