IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 6, Issue 10, October 2017

Dynamic Reliable System for Reducing Collision in Vehicular Networks Using Fuzzy Logic

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Abstract: Most collision avoidance systems currently under investigation are based on road vehicle or inter-vehicle communication. However, reliability remains an issue, as high mobility often leads to message collisions and link breakage. This work proposes vehicle collision avoidance system using wireless communication. We consider the problem of collision avoidance at vehicular intersections for a set of controlled and uncontrolled vehicles that are linked by wireless communication. In this work, it designs a controller using fuzzy approach for controlling the movement of vehicle. This system contains a sensor set, a managing unit and a monitoring platform. The collected data will be transmitted wirelessly to monitoring platform for data processing. Collision Avoidance systems, as a subsequent step to collision mitigation, are one of the Great challenges in the area of active safety for road vehicles. The mission is to reduce number of deaths and injuries on our roadways. For this, it designs a controller using fuzzy approach for controlling the movement of vehicles that helps to maintain a distance between vehicles. The main part of the work was to carry out a feasibility study on vehicle collision avoidance system using wireless communication.

Keywords: VANET, Wireless Communication, Vehicle Collision Avoidance, Fuzzy Controller etc.

I. INTRODUCTION

Wireless communication involves the transmission of information over a distance without help of wires, cables or any other forms of electrical conductors. An electromagnetic signal is created, modulated, amplified, and broadcast to one or more receivers that can be fixed or mobile. The transmitted distance can be anywhere between a few meters (for example, a television's remote control) and thousands of kilometres (for example, radio communication). Some of the devices used for wireless communication are cordless telephones, mobiles, GPS units, wireless computer parts, and satellite television. A defining characteristic of the mobile wireless channel is the variations of the channel strength over time and over frequency. According to recent standardization activities in Europe and the U.S., the first generation of inter-vehicle communication networks will be based on the IEEE 802.11p standard for wireless access in vehicular environments (WAVE). The medium access control (MAC) mechanism that will coordinate concurrent access in such networks is therefore Carrier Sense Multiple Access (CSMA). With CSMA, each node in the network performs a clear channel assessment prior to an own packet transmission and delays the transmission in case a busy channel is determined.

One of the first research projects that considered the exchange of information using wireless communication technologies was carried out from 1973 to 1979 in Japan, with the objective to develop a Comprehensive Automobile Traffic Control System (CACS) that reduces road traffic congestion and exhaust fumes, avoids traffic accidents, and enhances the public and social role of automobiles. Although the project was able to setup a pilot operation with 330 test vehicles and 98 roadside units in the end, CACS was never implemented on a large scale.
The success of the IEEE 802.11 WLAN technology, the availability of a satellite based global position system (GPS), and the allocation of a 75 MHz bandwidth in the 5.9 GHz frequency band by the US Federal Communication Consortium in 1999 stimulated a shift in the focus of subsequent research projects. These studies put more emphasis on the evaluation of architecture and protocol related issues, on a systematic exploration of possible application scenarios and use cases, as well as on the analysis whether the IEEE 802.11a standard specification is suited to support these applications and able to serve as a foundation for inter-vehicle communication systems.

It is possible for communicating vehicles to use both infrared and radio waves. VHF and microwaves are a type of broadcast communication while infrared and milli-meter waves are a type of directional communication. The Medium Access Control (MAC) layer protocols used in inter-vehicle communication are addressed, as are routing protocols. An ad-hoc network between vehicles is better suited for vehicle communications than centralized service. The centralized

architecture is not very efficient since information has to go from one vehicle to a central base station and then back to another vehicle. Some of telemetric applications require vehicle-to-infrastructure (V2I) data transfer, whilst others are vehicle-to-vehicle (V2V). This section provides literature survey related to vehicle collision avoidance system and provides various approaches related to them. Some authors [1] described the chance of smart video security system implementation. Authors [2] developed a system for collision warning for detecting vehicles ahead and also used to identify safety distance for assisting a distracted driver prior to crash. Researchers [3] presented a real time system for collision avoidance. It was based on characterizing with B-Spline curves. Authors [4] presented a Wireless based system that was capable of detecting vehicle collisions with motorways guardrail. Researchers [5] proposed a resolution algorithm using contention window. As the contention resolution system in IEEE 802.11, binary exponential back-off (BEB) has long been criticized because of its high collision probability in diffusion situation. Authors [6] considered the collision avoidance problem at vehicular intersections for different types of vehicles in controlled and uncontrolled manner.
In this paper, it studies the concept of vehicle collision avoidance system using wireless communication. Further, in section II, it provides the description of inter vehicle communication. In Section III, It defines the introduction of fuzzy logic. The proposed system is described in section IV. The results are presented in section V. Finally, conclusion is explained in Section VI.

II. INTER VEHICLE COMMUNICATION

A Vehicular Ad-Hoc Network is a technology that uses moving vehicles as nodes in a network to create a mobile network. VANET turns every participating vehicle into a wireless router or node, allowing vehicles approximately 100 to 300 meters of each other to connect and, in turn, create a network with a wide range. VANET is a subgroup of MANET where the nodes refer to vehicles. The primary goal of VANET is to provide road safety measures where information about vehicle's current speed, location coordinates are passed with or without the deployment of Infrastructure [3].

Paradigms are proposed for vehicular communications are:

- Vehicle to Vehicle (V2V)
- Vehicle to Infrastructure (V2I)

1. Vehicle to Vehicle Communication (V2V)
Vehicle to Vehicle communication approach is most suited for short range vehicular networks. It is fast and Reliable and provides real time safety. It does not need any roadside Infrastructure.V2V does not have the problem of Vehicle Shadowing in which a smaller vehicle is shadowed by a larger vehicle preventing it to communicate with the Roadside infrastructure.

2. Vehicle to Infrastructure (V2I)
Vehicle to Infrastructure provides solution to longer-range vehicular networks. It makes use of pre-existing network infrastructure such as wireless access points (Road-Side Units, RSUs). Communications between vehicles and RSUs are supported by Vehicle-to-Infrastructure (V2I) protocol. The V2I infrastructure needs to leverage on its large area coverage and needs more feature enhancements for Vehicle Applications [4].

Challenges in Inter-Vehicle Communication
Within the research community and standardization bodies, there is a common agreement that the following requirements have to be met by an inter-vehicle communication network that aims to increase the safety level on the road:

- The network has to support two types of safety messages: periodic awareness Messages which are broadcasted by any vehicle to inform neighbouring vehicles about the own presence and status, as well as event-driven alert messages which are sent out in case of an emergency situation that requires an immediate notification of possibly affected neighbours. Whereas periodic messages are envisioned to be only one-hop broadcasted and termed either Cooperative Awareness Message (CAM) or simply "beacon", event-driven messages may be disseminated over more than one hop.
- Although periodic beacon messages are the building block for a communication based active safety system, the importance of their content is typically lower compared to the content of an event-driven message. Consequently, the communication system should be able to differentiate between both types and assign higher priorities to emergency messages whenever they need to be disseminated.
- Due to the wide range of scenarios in which inter-vehicle communication networks will be deployed, the underlying communication system has to cope with a wide range of environmental conditions while providing optimal performance, hence it needs to be adaptive and robust.

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- The network has to support scenarios in which only a small number or up to several hundreds of vehicles have to communicate, hence it has to be elastic and scalable.
- Apart from the requirements described above, several challenges have to be faced, in particular by the physical layer and the medium access control layer:
- Due to the lack of a central coordination entity, communication will be performed in a distributed manner. This implies that resource and bandwidth allocations have to be determined in a self-organized fashion. However, since every vehicle acts out of its own perspective, message (or packet) transmissions by multiple vehicles will be difficult to synchronize, multiple access interference (or packet collisions) will not be an exception, and suboptimal medium access coordination among vehicles has to be expected.
- Frequent topology changes as a result of high vehicular mobilities prohibit a simple 1:1 adoption of principles that have shown to work efficiently in static networks. For instance, an offline (or a priori) optimization of the MAC layer, an approach that is often used in static networks, is not able to adapt to the topology changes that exist in vehicular environments [5].
- The IEEE 802.11a standard specification, from which IEEE 802.11p has been derived, was not optimized for a usage in vehicular environments in which the radio channel is fading significantly with respect to time and frequency domain. As a result, successful packet reception will be challenged even in the absence of interference.

III. INTRODUCTION TO FUZZY LOGIC

The Fuzzy Logic tool was introduced in 1965, also by Lotfi Zadeh, and is a mathematical tool for dealing with uncertainty. It offers to a soft computing partnership the important concept of computing with words'. It provides a technique to deal with imprecision and information granularity. The fuzzy theory provides a mechanism for representing linguistic constructs such as "many," "low," "medium," "often," "few" as shown in fig 1.

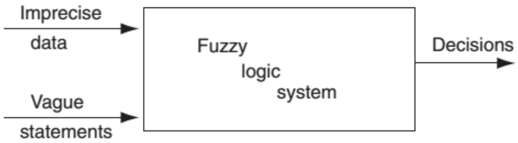

Fig 1: A Simple Fuzzy Logic System [10]

Fuzzy set theory provides a systematic calculus to deal with such information linguistically, and it performs numerical computation by using linguistic labels stipulated by membership functions. A fuzzy inference system (FIS) when selected properly can effectively model human expertise in a specific application. A classic set is a crisp set with a crisp boundary. In contrast to a classical set, a fuzzy set, as the name implies, is a set without a crisp boundary. That is, the transition from "belongs to a set" to "does not belong to a set" is gradual, and this smooth transition is characterized by membership functions that give fuzzy sets flexibility in modelling commonly used linguistic expressions, such as "the water is hot" or "the temperature is high". The fuzziness does not come from the randomness of the constituent members of the set, but from the uncertainties and imprecise nature of abstract thoughts and concepts. The construction of a fuzzy set depends on two things: the identification of a suitable universe of discourse and the specification of an appropriate membership function. Therefore, the subjectivity and non-randomness of fuzzy sets is the primary difference between the study of fuzzy sets and Probability Theory. Fig 2 denotes the membership function for left and right obstacle distance. It helps the vehicle for preventing collision from sides of wall or road.

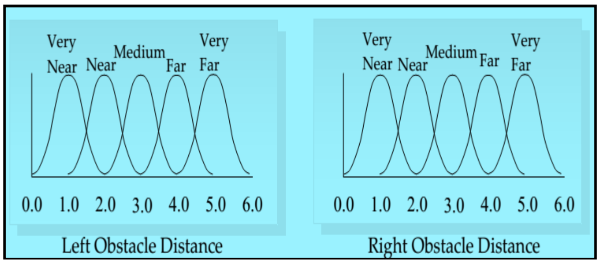

Fig 2: Membership Function of Left and Right Obstacle Distance

In fuzzy system, the fuzzifier performs measurements of the input variables (input signals, real variables), scale mapping and fuzzification (transformation 1). Thus all the monitored signals are scaled, and fuzzification means that the measured signals (crisp input quantities which have numerical values) are transformed into fuzzy quantities. This transformation is performed using membership functions. In a conventional fuzzy logic controller, the number of membership functions and the shapes of these are initially determined by the user. A membership function has a value between 0 and 1, and it indicates the degree of belongingness of a quantity to a fuzzy set. Once the linguistic variables and values are defined, the rules of the fuzzy inference system can be formulated. These rules map the fuzzy inputs to

DOI 10.17148/IJARCCE.2017.61057

fuzzy outputs. This mapping takes place through compositional rule of inference which is based on Zadeh's extension of modus ponens which is nothing more than the familiar if-then conditional form. A fuzzy if-then rule (also known as fuzzy rule) assumes the form.

If x is A then y is B.

The membership functions can take many forms including triangular, Gaussian, bell shaped, trapezoidal, etc. The knowledge base consists of the data base and the linguistic control rule base. The data base provides the information which is used to define the linguistic control rules and the fuzzy data manipulation in the fuzzy logic controller. The rule base defines (expert rules) specifies the control goal actions by means of a set of linguistic rules. In other words, the rule base contains rules such as would be provided by an expert.

Table 1: IF-THEN Rules for Linguistic Variables

IF	THEN
L_Dist is Far and R_Dist is Far	R_Vel is high, L_Vel is high
L_Dist is Near and R_Dist is Near	R_Vel is Slow, L_Vel is high
L_Dist is Near and R_Dist is Medium	R_Vel is Slow, L_Vel is Slow
L_Dist is Near and R_Dist is Far	R_Vel is Slow, L_Vel is Slow

IV. PROPOSED IMPLEMENTATION OF SYSTEM

There are more than 1,700 fatalities and 840,000 injuries yearly due to vehicle crashes off public highways. Car crashes are the number one killer of children 1 to 12 years old in the United States. Passenger vans handle very differently from smaller passenger vehicles because they are typically longer, higher, and wider. They have a higher risk of crashes and rollovers if not properly driven and maintained. For this, it considers the problem of collision avoidance at vehicular intersections for a set of controlled and uncontrolled vehicles that are linked by wireless communication. Collision avoidance in networking mainly appears in networks with carrier sense multiple accesses. This is based on the principle that nodes that are willing to transmit data have to listen to the channel for some time to determine whether other nodes are also transmitting on the wireless channel. Nodes within senders and receivers are alerted not to transmit for the duration of main transmissions. The network has to support two types of safety messages: periodic awareness Messages which are broadcasted by any vehicle to inform neighbouring vehicles about the own presence and status, as well as event-driven alert messages which are sent out in case of an emergency situation that requires an immediate notification of possibly affected neighbours. Whereas periodic messages are envisioned to be only one-hop broadcasted and termed either Cooperative Awareness Message (CAM) or simply "beacon", event-driven messages may be disseminated over more than one hop. The network has to support scenarios in which only a small number or up to several hundreds of vehicles have to communicate, hence it has to be elastic and scalable.

```
Case 1: if vehicle moving in single lane then
        If V are in same direction then
        If distance between V is less< threshold then
        BS message to V to maintain the distance to
        avoid collision
        end
        end
        If V are in opposite direction then
        If side distance between V is less< threshold
then
        BS message to V to maintain the side distance
        end
        end
        End
Case 2: if vehicle moving in double side lane then
        If distance between V is less< threshold then
        BS message to V to maintain the distance to
        avoid collision
        End
        End
Case 3: if vehicle moving in Traffic lane then
        If small traffic is present then
        BS message to V to avoid traffic
        End
        If complete lane is blocked then
        BS message to V to change the lane
        immediately
        End
        End
END
```

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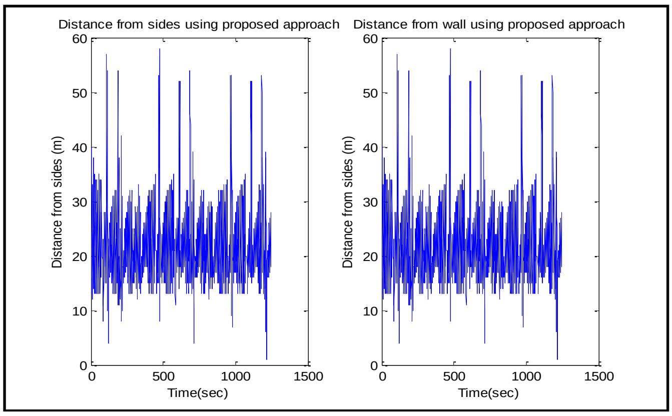
The mission of this module is to detect and track obstacles and determine their speed and direction while distinguishing between obstacles that are within the area of interest and may present a risk, and those that are outside. Positioning of the vehicle and the obstacles in accurate and detailed digital maps provide extra information. It decides the best possible action to take to avoid an accident or reduce its consequences based on the information from the surroundings. Its premise is not to generate any additional risks for other road users. This decision module should take into account the road characteristics, the own vehicle movement, the obstacles and should generate manoeuvres that are feasible in practice according to vehicle dynamics and should not be surprising for the drivers. In this work, it considers the vehicle collision avoidance at rural areas in nation. For this, it uses a fuzzy controller for controlling the movement of vehicles. The vehicle used here are rear wheel drive having two rear wheels, namely left and right rear wheel. The vehicle considered in this thesis is a car or bus for simulation mode. Each vehicle has an array of sensors for measuring the distances around it and locating the target i.e., front obstacle distance (FD), left obstacle distance (LD), right obstacle distance (RD) and detecting the bearing of target. The distance between the vehicle and obstacles act as repulsive forces for avoiding the obstacles, and the bearing of the target acts as an attractive force between vehicles and target. Linguistic variables such as "far", "medium" and "near" are taken for membership function.

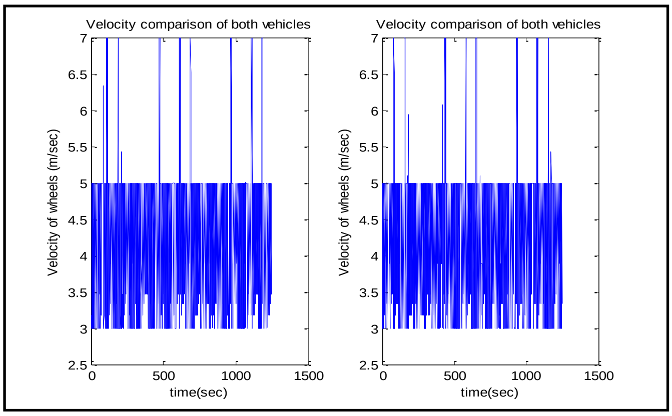
V. RESULTS FOR PROPOSED SYSTEM

The proposed system assists the driver at cross roads. The traffic patterns at street corners are unpredictable and can often lead to dangerous situations. In first case, only single lane is available for moving the vehicle. In case the car is going in front side if there is any vehicles is coming in side direction means our both sides of the sensor will detect. The driver can easily stop or save the car from accidents. The base station is provided in the road side. If there is any vehicle wants to cross or overtake the another vehicle and if there is distance between vehicle is less as compared to threshold then base station immediately sends the message to vehicles to reconfigure the distance and velocity.

In 2nd case, two lane roads are available for moving the vehicle. In case the car is going in front side if there is any vehicles is coming in side direction means our both sides of the sensor will detect. In this, it uses the fuzzy controller for controlling the movement of vehicles. It requires position of vehicle as input and provides velocity as an output. These parameters will used to estimate the collision probability of vehicle. The main parameters are velocity of vehicle, angle of orientation, distance from wall and time of simulation etc.



(A)



(B)

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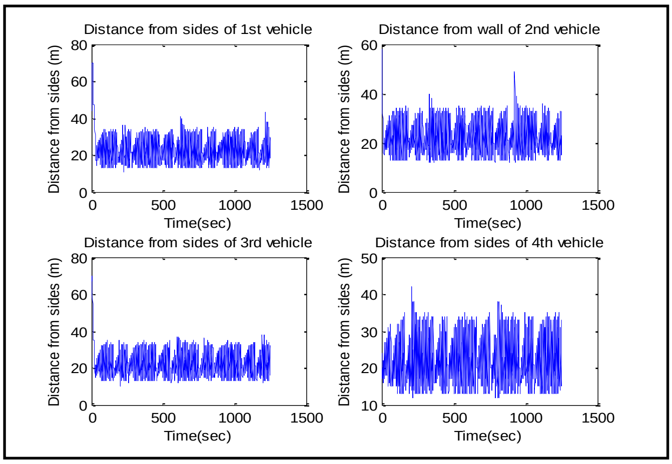

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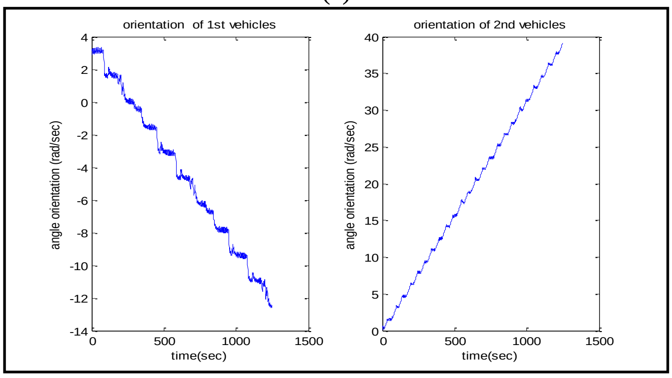

(D)

Fig 3: Scenarios for Collision Avoidance System in Areas a) 2 Vehicle in Single Lane b) 4 Velocity of Vehicle in Single Lane c) 4 Vehicles Moving in Same Direction in Same Lane d) 2 Vehicle Moving in Opposite Direction

VI. CONCLUSIONS

Driving safety is an important issue. It considers the problem of collision avoidance at vehicular intersections for a set of controlled and uncontrolled vehicles that are linked by wireless communication. The foremost objective of work is to prevent rural intersection collisions. In this case, vehicle is controlled by fuzzy controller and communicates by base station present on roadside. If distance between the vehicles is less, then their speed is controlled by controller and hence it avoids the collision between them. In this work, it presents the scenario for rural areas mainly. It presents the scenario with two and four vehicles in a single lane or two lane areas. It follows the rule of left side travelling in each scenario by the use of controller. The path of projection of vehicle is also presented by the use of controller. Their velocity of propagation, distance from sides and angle of orientation are also measured and evaluated.
The future work includes lane detection under hilly areas under heavy traffic. Also implement this system with hardware configuration.

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