VANET Based Proficient Collision Detection and Avoidance Strategy for Cars using DOUBLE-C Curve Movement Algorithm

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ABSTRACT

Pervasive computing is a growing technology that aims for an environment where computer becomes nearly invisible but still be used. This model used for human-computer interaction has been implemented to some extend at various fields. The paper discusses about various VANET technologies used such as adaptive cruise control system, advanced diagnostic and control system, the intelligent parking assist system, forward collision avoidance system and electronic stability system in brief. The paper proposes an efficient method for collision detection and avoidance using VANETs. An algorithm to generate a DOUBLE-C curve movement for the collision avoidance mechanism is also presented. Thus providing a more enhanced way to avoid crash of vehicles in high ways, blind corners, lane shifts etc.

Keywords

IPAS, APGS, ECS, cone movement, DOUBLE-C curve movement, VANET-Vehicular Ad-Hoc Network.

1. INTRODUCTION

The essence of the pervasive computing was the creation of environments saturated with computing and communication capability, yet gracefully integrated with human users. Pervasive computing used in cars is a natural approach to enhance the living environment as cars are an integral part to the current society. Cars nowadays are embedded with micro processing chips in their engine. These monitor the braking system, air bag system, wheeling etc. to provide a comfortable and safe driving experience. This paper presents a collision detection technique using the cone movement and collision avoidance technique. Apart from this the paper proposes a new algorithm called DOUBLE-C curve movement for the alternative path to be taken by the vehicle in case of collision detection.

2. BACKGROUND

Adaptive cruise control is a radar-based system that can monitor the vehicle in front (up to 600 feet) and adjust the speed of the vehicle to keep it at a preset distance behind the lead vehicle, even in most fog and rain conditions. The system measures distance as a function of speed and can monitor the traffic ahead while ignoring stationary objects such as road signs and telephone poles. It also can determine how fast the vehicle is approaching the vehicles ahead. For example, when approaching a lead vehicle at a high rate of speed, the system will activate sooner than when approaching slower .Four distance settings accommodate a range of driving styles and road conditions. The driver can set distance, speed and the time gap between vehicles. With speed settings as low as 20 mph, the driver can set the system to work as well during normal commuting as it does on the highway. [5]Intelligent Parking Assist System (IPAS), also known as the Advanced Parking Guidance System (APGS), ahybrid Prius model was the first parking assist system developed by Toyota Motor Corporation in 2004 for the Japanese market and later it wasextended to the Lexus models in the United States. The technology assists drivers in parking their vehicle. The initial version of the Intelligent Parking Assist System[5], launched in 2003 was designed for reverse parallel parking. Driver intervention was not required, as the system estimated the size of the parking space and maneuvered the vehicle appropriately. This was done by an onboard computer which used a camera built into the forward and rear of the car. Sensors located at similar locations detected the proximity of nearby vehicles. The dashboard displayed an image of the lot, and the driver would then have to determine the exact position that the vehicle in the lot via the arrows which appeared on the screen. Using the arrows, the user would set the location of the vehicle in the space. When satisfied, the user pressed the "Set" button, which then activated the IPAS. The system then took over steering control to maneuver the vehicle.[3] This latest version could calculate the steering maneuvers needed for parallel or reverse parking, and help determine that the car has enough clearance for a particular space with colored screen displays which indicated adequate or inadequate space. [4]

Frontal collision warning/collision avoidance (CW/CA) systems target a major crash type –rear-end crashes with a moving or parked vehicle – which account for 35% of all accidents. These active safety systems are a natural extension of adaptive cruise control (ACC) systems due to their similarity in hardware requirement. Therefore, CW/CA systems are expected to take off quickly, in a fashion similar to the success of vehicle stability control systems. Due to the difference in product segmentation (safety vs. comfort) however, many car manufacturers are much more cautious in CW/CA product design and launching. In addition to legal/liability concerns, this conservativeness is mainly due to the heavier reliance of CW/CA systems on human follow-up actions. In the case of ACC, the product is designed to keep the vehicle operating in regions where human intervention is normally unnecessary (safe time headway, small relative speed). Therefore, the characteristics of the human driver are relatively unimportant.In the case of CW/CA however, the human driver is always in control and could encroach on safe driving boundaries. Furthermore, the driver is responsible for reacting to the warning signal in a proper fashion solely or together with the automatic braking system. Therefore, designing a CW/CA system that can accommodate a wide range of human characteristics is non-trivial. [5]Electronic stability control (ESC), also referred to as electronic stability program (ESP) or dynamic stability control (DSC), is a computerized technology that improves the safety of a vehicle's stability by detecting and reducing loss of traction (skidding). During normal driving, ESC works in the background and continuously monitors steering and vehicle direction. It compares the driver's intended direction (determined through the measured steering wheel angle) to the vehicle's actual direction (determined through measured lateral acceleration, vehicle rotation (yaw), and individual road wheel speeds).[1]ESC intervenes only when it detects a probable loss of steering control, i.e. when the vehicle is not going where the driver is steering. This may happen, for example, when skidding during emergency evasive swerves, under steer or over steer during poorly judged turns on slippery roads, or hydroplaning. ESC may also intervene in an unwanted way during high-performance driving, because steering input may not always be directly indicative of the intended direction of travel (i.e. controlled drifting). ESC estimates the direction of the skid, and then applies the brakes to individual wheels asymmetrically in order to create torque about the vehicle's vertical axis, opposing the skid and bringing the vehicle back in line with the driver's commanded direction. Additionally, the system may reduce engine power or operate the transmission to slow the vehicle down. It reacts to and corrects skidding much faster and more effectively than the typical human driver, often before the driver is even aware of any imminent loss of control. In fact, this led to some concern that ESC could allow drivers to become overconfident in their vehicle's handling and/or their own driving skills. For this reason, ESC systems typically inform the driver when they intervene, so that the driver knows that the vehicle's handling limits have been approached. Most activate a dashboard indicator light and/or alert tone; some intentionally allow the vehicle's corrected course to deviate very slightly from the driver-commanded direction, even if it is possible to more precisely match it.ESC does not increase traction, so it does not enable faster. More generally, ESC works within inherent limits of the vehicle's handling and available traction between the tires and road. A reckless maneuver can still exceed these limits, resulting in loss of control.[5]

3. PROPOSEDMODELFOR COLLISION DETECTION AND AVOIDANCE

The GPS system is used to deduce the path to be taken by the driver to reach his destination. Then an overall traffic report is generated based on the roads he has planned to take by referencing to the database from the VANET(Vehicular ad-hoc network)traffic information sharing system presented in [9].When the driver starts off in his trip the GPS and speedometer collectively records the speed and the position of the vehicle at specific time intervals lesser than the average collision time. This information along with the angle of turn for the vehicle is then reported at both the vehicles under consideration.

A movement in the form of a cone is assumed for all vehicles and using the position and speed rates from the speedometer, the collision zone is detected. The distance and time for collision is calculated. The cone dimensions are generated using the basic arc formula in geometry. According to the data obtained, collision zone area is reduced by controlling the speed and direction of the two vehicles involved. This is accomplished by directly interacting with the braking system and the steering system based on the data inferred and the proposed DOUBLE-C curve algorithm.

3.1 Algorithm

step-1: *Start*
step-2: *Deduce the path to be taken to reach destination.*
step-3: *Plan traffic free routes using the VANET traffic information sharing system.*
step-4: *Record speedometer and GPS readings.*
step-5: *Transfer GPS, speedometer reading and angle of turn are reported through VANET.*
step-6: *Generate Cone movement.*
step-7: *Estimate Collision area.*
step-8: *Control braking and steering systems accordingly.*
step-9: *Stop*

3.2 Collision Detection

Radar based collision detection technique[5], or more formally the forward collision detection has its own limitations that it can only detect collision when the vehicle is in the front or rear and at close proximity. Another approach is that the direct neighbor vehicle exchange their position and speed information that were gathered from the GPS using single-hop WLAN communication which have a 360◦ angle of coverage. However, since this kind of information exchange introduces the problem of hidden vehicles, where the wireless transmitters of possible colliding vehicles are not in range with each other. This type of collision detection technique consumes more time, therefore any collision cannot be averted by the driver at the appropriate time. These types of detection system serve very limited purpose in blind corners and in highways. [2][6]

The proposed system uses the following : the GPS location of the vehicle with the latitude and longitude values, the speedometer reading to calculate the current speed and acceleration of the vehicle, the maximum angle range for the wheels turn(varies with vehicle) , and the stopping distance of the vehicle (varies with vehicle). Data transfer is carried out through multi hop routing protocols that can achieve high end to end package delivery ratio with low overhead in VANETs.

The information exchange takes place through the VANET and every package that is transferred consist of the following: ID of the vehicle, the location of the vehicle, the acceleration of the vehicle, the angle of turn for the vehicle, the stopping distance for the vehicle at that instance and the time of reporting the information. This information packet is sent to every nearby VANET nodes to the current vehicle at a timely basis of very small and finite interval. Using this information received from the neighboring vehicle and the same data of the considered vehicle, a 2D cone of movement is generated with GPS location points and approximately calculated estimation time for it. The radius of the arc drawn is the stopping distance of the vehicle. The angle of the arc is the angle of turn of the wheels. The cone of movement is used to predict collision points for the vehicle and is calculated using

$$\textit{Area of cone movement} = (\alpha/360)*\pi*(d)^2$$

Where α is the angle of turn for the vehicle and d is the stopping distance for the vehicle.

3.3 Collision Avoidance

Once the collision zone is detected and the possible collision is identified, the collision avoidance technique to stop this collision is performed. As the vehicle approaches near each other, the collision zone area becomes larger. The first approach to avoid is the already present adaptive cruise control technique, where the braking system is controlled by the computer automatically and the vehicles maintain optimal distance from one another thereby averting collision. But this system has its implementation only based on the lead vehicle. Since collision is possible even at blind corners and while changing lanes in highway where lead vehicles are absent, this system possess a limitation.

In order to overcome this problem, the proposed model controls the steering system along with the braking system thereby taking the vehicles apart from each other, taking over the wheels automatically only when a plausible collision is detected. Once the collision is detected, the number of collision points is calculated. Based on this number and its comparison with a preset value, the braking system may be operated either autonomously or in combination with the steering system. [7] The force applied on the braking system is calculated proportional to the difference between the number of collision points and the preset points. Steering system is combined only if there is sufficient space and time between the vehicles to achieve a path for it. The steering process follows a DOUBLE-C curve movement approach to ferry the vehicles away from colliding with each other. The modified path information is also added to the information packet sent.[8] The information packet sent for this purpose contains the following details: ID of the vehicle, time when data is reported, current position of the vehicle, future position of the vehicle that causes collision, estimated time for collision, alternate path as a series of latitude and longitude, and previous collision zone area.

4. ALGORITHM FOR ALTERNATE PATH GENERATION

When two vehicles come close to each other the information of their cone of movement is exchanged through VANET. A series of collision points are calculated and compared with the preset threshold number of collision value. The stopping distance of the two vehicles also plays a crucial role in calculation of the preset value. if the points exceed threshold value, it means the space and time of collision is very short therefore the forceful brake is applied to completely stop the vehicle. Force applied is proportional to the difference in the calculated number of collision points and the preset points .If the points do not exceed threshold value, it means there is ample time before the collision takes place so the vehicles can be steered away from each other. An alternate path is generated with the DOUBLE-Ccurve movement and the vehicle avoids collision.

```
step-1:  Start
step-2:  Exchange cone of movement information.
step-3:  Calculate and compare collision points with preset value.
step-4:  If the STEP-3 value is positive , GOTO STEP-5 else perform decision level II.
step-5:  Apply forceful brake proportional to difference in comparison.
step-6:  Stop
```

5. DOUBLE-CCURVE MOVEMENT FOR COLLISION AVOIDANCE

In the proposed model we split the DOUBLE-C curve which is in the form of an inverted "S" shape is split into two. The shape that looks like a "C" is considered the DOUBLE-C left curve and the one that looks like an inverted "c" is considered the DOUBLE-C right curve. As collision is detected and the decision is made to perform change of direction for the vehicle, the vehicle's cone of movement is downsized to a straight line motion. Once the straight line movement is designed collision points are now converted to a single point.[1]A DOUBLE-C left curve movement is employed in both the vehicle in such a speed that there is sufficient time lag at the meeting points of their respective DOUBLE-C curve path. Moreover angle of the turn is decided based on the lane width that might be known from the lane departure warning system that may already be present in the vehicles. When there is no sufficient space to perform a left curve movement, the DOUBLE-C right curve is performed. This is determined easily by noting the current angle of the vehicle that will be varied from neutral position during bends.

```
step-1:  Start
step-2:  Decision level II
step-3:  Downsize vehicle's cone of movement to straight line motion.
step-4:  Observe point of collision.
step-5:  Perform DOUBLE-C left curve movement with time lag.
step-6:  If STEP-5 leads to collision or lane shifts, GOTO STEP-7
step-7:  Perform DOUBLE-C right curve movement with time lag.
step-8:  Stop
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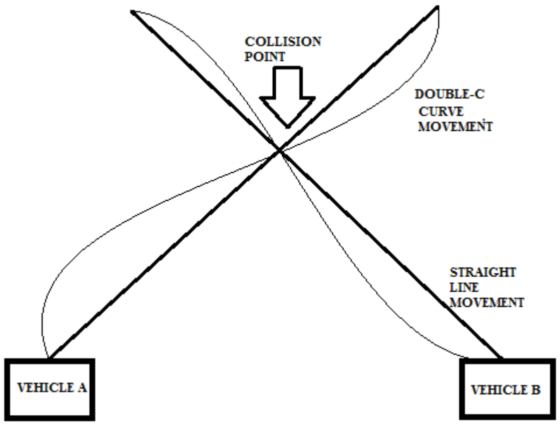

Figure 1: Block diagram to represent DOUBLE-C curve movement.

6. CONCLUSION

Collision avoidance is a crucial area to work at as there is an increased rate of accidents in various countries due to the increase in the number of vehicles on the roads. So any valid model that can curb this to some extend will be vital to the society. The paper proposes such a model for collision detection using the cone of movement analysis and the collision avoidance algorithm using the DOUBLE-C curve approach. This model will reduce the collision occurrence to a great extent and thereby increases road safety, enhances the ease of travel on roads. Collision detection operations will be done at a faster rate as the data are sent as packets and the calculation is done separately after it is received instead of calculating in one node and sending it to the other. This model could also be used as a basis for many other new models,may be developed in future. A few limitations that this model might pose are that commercial production of the system might be expensive; DOUBLE-C Curve Movement may not work at specific angles of collision. Especially when two vehicles are moving in parallel where no collision should be detected yet the collision zone will be calculated .It can be implemented in vehicles which serve as VANET nodes as data are transferred through these nodes to generate the respective cone of movement.

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