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Automatic Vehicle Collision Avoidance System - A Survey.

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ABSTRACT

Collision avoidance is a greatest challenge in the world but with the enhancement of emerging embedded technologies in automotive field, the life of people becomes more comfortable and provides safety against accidents. With more than one death and four injuries every minute, India has the dubious distinction of reporting highest number of road fatalities in the world and the government says the prime reason is "drivers' fault". In India most of the road accidents are happened due to distracted driving, drowsy driving, over speeding, drunk driving etc. The main aim of this paper is to review the various research papers related to automatic vehicle collision avoidance system. Some of the reviewed work include braking system which senses an obstacle using ultrasonic sensor and calculate relative distance and apply brake automatically. By using Alcohol sensor, eye blink sensor drunken driver, driver fatigue condition can be avoided. Obstacle and track deviation is identified by camera and imaging system.

Keywords: Collision avoidance, driving, objet detection, sensors etc..

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INTRODUCTION

World Health Organization reveals that every hour, 40 people under the age of 25 die in road accidents around the globe. According to the WHO, this is the second most important cause of death for 5 to 29 year olds. The NCRB report further states that drunken driving was a major factor for road accidents. "Most of the city accidents are not necessarily out of drunken driving," says Pereira. But 99% of the accidents, the fatal accidents that occur outside the cities are due to drunken driving and there is no check on this kind of drunken driving. Unfortunately, truck drivers think they are fully armed to drive on the highway when they are fully drunk! Until and unless this country comes up with a new method of checking drunkenness on the highways".

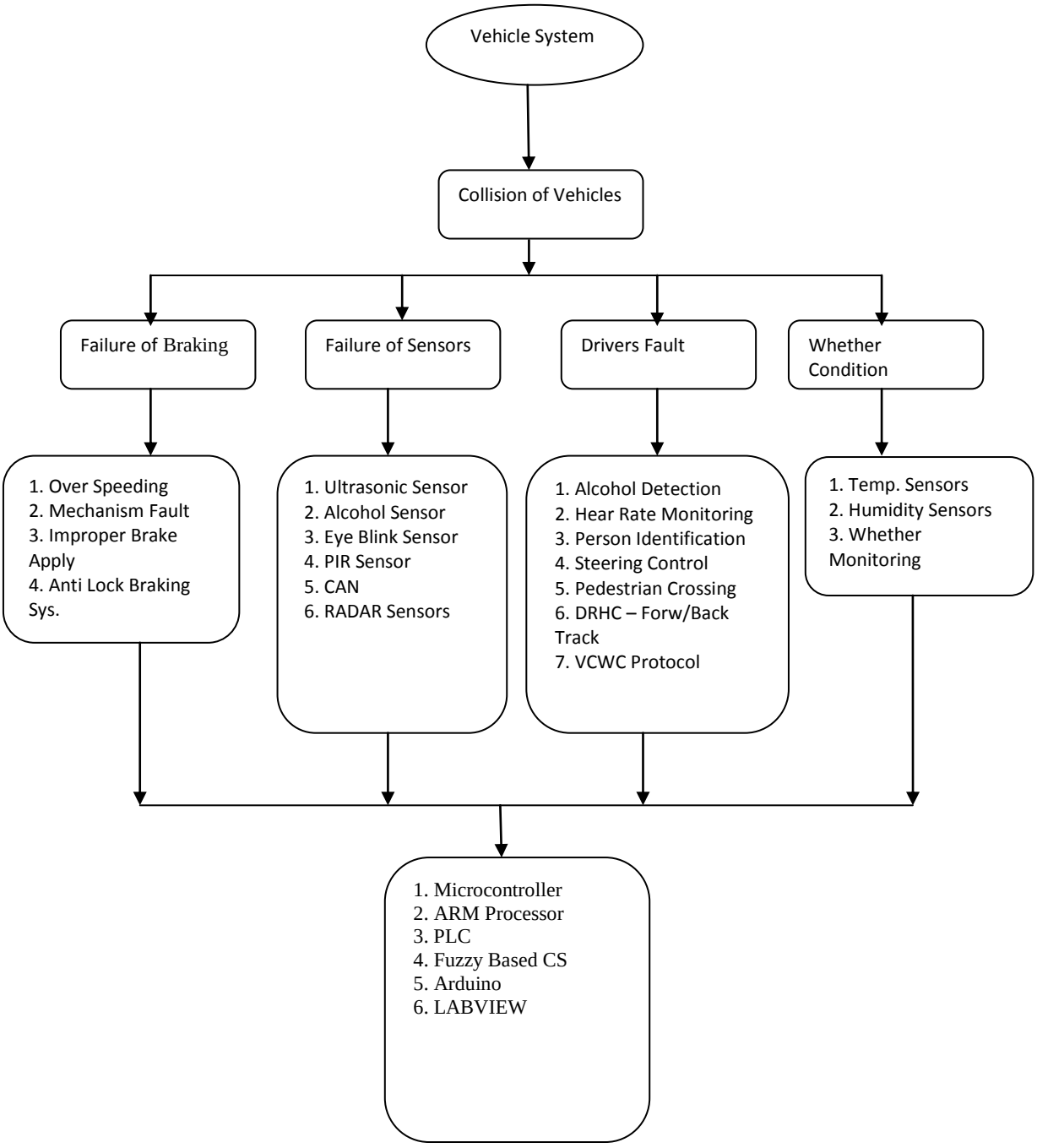

Fig.1 Collision Avoidance System – Literature – Block Diagram

A collision avoidance system is an automobile safety system designed to reduce the severity of an accident. The increasing number of traffic accidents in recent years has assumed the dimensions of a serious social problem, making it imperative to find effective ways of reducing traffic accidents and fatalities. As an initial step in this direction, it is important to identify the elements of the problem through analysis of its mechanism. Traffic accidents involve different processes according to where the accident occurs and in what situation the collision occurs. Of the three main elements involved in an accident, i.e., the driver, the vehicle and the environment, the main cause of accidents has been identified as the driver. Because of health conditions, psychological factors, or lack of concentration, drivers often fail to stop in time, causing accidents.

The increasing demand of embedded technologies in automotive industry provides a better and reliable safety feature for the passenger and driver safety. A number of obstacle detection system are introduced provides safety measures and increase the transport efficiency. Autonomous vehicle technology are implemented in most of the vehicles nowadays which includes a number of sensors to detect the obstacles in front, side and rear of the vehicle .

The block diagram in Fig.1 represents the various causes of collision avoidance system. The rest of the paper is organized as follows. The literature review of the each block has been summarized in the section 2. Section 3 concludes the related work of the vehicle collision avoidance system.

LITERATURE SURVEY

Dr.N.Jaisankar et al [1] proposed standard algorithms for anti collision avoidance systems and reviewed automatic braking system that safely stops an automobile while approaching an obstruction to avoid collision. Another separate but related system is to have a detection device, which alerts the driver in case the automobile veers off the road by crossing either the centre or side painted lines. The braking system senses an obstacle, calculates the relative distance and applies the variable brakes automatically to maintain a safe distance. Warning devices and sensor mechanisms used in obstacle avoidance systems are also reviewed.

Mazda Algorithm

Mazda Algorithm proposed to estimate the minimum distance, which should be followed between the lead and host vehicles.

Berkeley Algorithm

Berkeley Algorithm proposed to estimate the warning range R_w. R_w is the minimum range buffer needed to avoid collisions until both vehicles come to a full stop, while the overriding range Ro estimated using Mazda algorithm only considers the range buffer needed from time 0 to τ. Here the lead vehicle brakes at the maximum constant deceleration level −α, while the host vehicle starts to brake after reaction time τ at the same deceleration level.

Honda Algorithm

Honda logic consists of both warning and avoidance algorithm and it proposes two concepts whether the lead vehicle should be stopped before or after τ2.The system gives a warning when the range *R* becomes less than the warning range *Rw* and applies the brakes automatically when *R* is less than *Ro Compare* to Mazda algorithm, Honda Algorithm gives smallest *Ro.*

NHTSA Algorithm

NHTSA algorithm tries to estimate the relative acceleration (aR ≡ aL − aH) in real time from the time derivative of range rate (RR) data measured by radar sensors, then the lead vehicle deceleration level aL is computed from aR estimation and aH measurement, in contrast to previous algorithms where aL is a preselected parameter. The driver reaction time tr, which includes both the driver and system delays, is normally set to 1.5 s, and is reduced to 0.5 s when brake is applied.

CRISS Driving Simulator

Francesco and Roberta conducted statistical analysis for collision warning. They have given a model,

$$\text{Distance} = 125\Delta V + 155V_f$$

Where ΔV and VF are expressed in m/s.

The distance (d) given by the model can be considered as a threshold which should trigger an alarm system for driver assistance. An alarm is provided when the driver is in the middle of the crash alert timing zone (in other words when t is 1.35s).

CAMP Alert Algorithm

The CAMP Alert Algorithm is similar to NHTSA Algorithm. The only differences are that Dthresh is set to zero and that aHmax is replaced by required deceleration aHreq. Hence aHreq varies according to the different underlying dynamic scenarios, and is not a pre- fixed parameter. The Crash Avoidance Metrics Partnership (CAMP) was established to accelerate the research in advanced automotive collision avoidance systems to improve traffic safety.

Mr.Ramchandra Patil et al.[2] implemented car block box using ARM to avoid vehicle collision. There are two main parts in his implementation such as vehicle to vehicle collision avoidance unit and black box. VVCAU is used to avoid collision between the vehicles and black box is used to record the relevant details about a vehicle such as Engine Temperature, Distance from obstacle, Speed of vehicle, Brake status, CO2 Content, Alcohol content, Accident Direction, trip Time and Date. The details recorded in black box are used to investigate the reason for an accident. In order to control the speed of the vehicle motor driving circuit is used. GSM concept is used for transmitting the status of car to the authorized person.

Mr.Md.Khaled Hossain et al.[3] proposed precrash detection and accident avoidance system. He was mainly focused on human sensing technology using passive infrared sensor. If any human or animal passes in front of the PIR sensor or any movement is detected of human or animal in front of PIR sensor it generates +5v and -5v sine signal. A breakout board is used to detect this signal and convert it into a longer digital signal.

Mr.S.Ramesh et al. [4] proposed laser sensor, CAN controller and wireless sensor network based vehicle collision avoidance system. Controller area network (CAN or CAN-bus) is a vehicle bus standard designed to allow microcontrollers and devices to communicate with each other within a vehicle without a host Computer. Wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location.

Mr.S.P.Bhumkar et al. [5] implemented a system to detect fatigue symptoms of drivers and control the speed of vehicle to avoid accidents. The main components of the system consist of number of real time sensors like gas, eye blink, alcohol, fuel, impact sensors and a software interface with GPS and Google Maps APIs for location. They have revised existing advanced system used in higher end cars such as ABS (Anti Lock Braking System), EBD (Electronic Brake Force Distribution), SRS Airbags, Immobilizer, Cruise Control, Parking Sensors.

Mr.Ka.C.Cheok et al. [6] proposed multi sensor based collision warning system. The warning system uses the following techniques for distance measurements such as radar, vision and sonar. This paper discusses the requirements and objectives for a collision warning system. The hardware setup and the distance control scheme are being investigated, along with a filtering technique for estimating ahead vehicle distance. Kalman filter fusion technique has been used to estimate the acceleration, velocity and headway distance.

Dr.H.Mangalam et al. [7] proposed Radar based vehicle collision avoidance system. Radar sensors are used to detect presence of moving objects in their vehicle path, predict the vehicle speed and direction, estimate the safest distance to be maintained between the vehicles. In this system the control unit compares

the actual speed with the desired speed. If there is difference between the values, throttle position actuator brings the vehicle to the set speed. During danger of collision, if the driver's response is delayed, the system will pre-charge the brakes to prepare the vehicle for more aggressive braking to help avoid rear-end accidents. Speed sensor sends the sensed information to the brake control module which compares it to the speed of other wheels. Pump valve assembly is used to apply increase in pressure to the wheels to slow down the vehicle while running faster. If both wheels are approximately the same speed the brake control module can enter a pressure hold mode of operation.

Mr.T.K.Srudeep Somnaath et al. [8] proposed autonomous remote control car with lane detection and collision avoidance system. For the distance measurement between the vehicles ultrasonic sensor is proposed. The lane line in the road was detected using infrared sensors.ARM processor is used in this system to drive the car automatically. For programming ARM, Keil µVision3 IDE was used.GSM technology was proposed to get commands from authorized person and act accordingly. If the owner sends the command "ON" the motors are turned on by the microcontroller and the vehicle will move forward.

Ms.Sumit Garethiya et al. [9] proposed advanced vehicle collision avoidance system using Raspberry-Pi. An ultrasonic sensor was used for the detection of real time moving and stationary objects under all weather environments. The proposed system consists of control unit with Raspberry-Pi board, ultrasonic sensors, display board and buzzer. When the vehicle starts to move the sensor started to sense the objects in front of the vehicle.LCD display is used to display the measured distance and LED & buzzer is used to ialert the driver so that driver can be able to apply brakes accordingly.

Ms.Shanmathi.S et al. [10] proposed Arduino based vehicle collision detection using CAN protocol. Ultrasonic sensor is proposed to measure the distance between the vehicles. If the driver appears to be drunk the vehicle automatically get stop through the information gathered from an alcoholic sensor. Bump sensor is used to detect an accident and send SMS to the hospitals and police station about the location of an accident. In vehicle there are so many Ecu's(Electronic control unit). Ecu's can be communicated among them with the help of CAN protocol. Proposed system consists of transmitter and receiver circuit. Sensors are placed at the transmitter side and ARDUINO Microcontroller and display devices are placed at the receiver side.

Dhivya.M et al. [11] implemented collision avoidance system based on Alcohol detection, Heart rate monitoring and Personal identification system. Alcohol consumption, heart rate, person identification is detected by the MQ3 sensor, Heart rate sensor and PIR sensor respectively. If the sensed value of the MQ3 and heart rate monitoring sensor are abnormal the relay will be activated by the controller and thereby the vehicle will automatically turns off. If the value sensed by the PIR sensor is abnormal the window of the vehicle will automatically get open. The overall system was implemented in LABVIEW.

S.Senthazhai et al. [12] Road adaptive overtake assistance system based dedicated short range communication is proposed to avoid rear end accidents. Radar technique was used to detect the distance between the vehicles. The proposed system consists of three modules. Such as control unit, monitoring unit, vehicle unit. The three units are communicating each other using MRF Transceiver. MEMS compass and MEMS accelerometer proposed to detect the direction of the vehicle and vibration of the vehicle correspondingly.

T.U.Anand Santhosh Kumar et al.[13] implemented collision avoidance system for bad weather conditions. In this system they have used Temperature sensor and humidity sensor to detect bad weather conditions and also they have used IR sensor and ultrasonic sensor to detect the distance between in front vehicle and adjacent vehicle. The IR sensor and ultrasonic sensor measures the safe distance between the vehicles. If the distance between the vehicles is increased beyond the threshold, the vehicle speed will be reduced automatically. When collision occurs the vibration sensor sense the accident and the ARM controller identify the location of an accident and send message via GPS and GSM.

Rabindranath Bera et al. [14] implemented remote sensing device(DSSS – Direct Sequence Spread Spectrum) for automatic cruise control in vehicles to avoid accidents. The digital radar can be able to detect multiple targets but it cannot able to differentiate the targets. In order to separate the target step frequency mode was used. From the MATLAB simulation they have identified that single frequency radar is unable to separate the different objects. So they have used frequency stepping to separate the objects.

Tsung-Ying Sun et al. [15] proposed vision perception and fuzzy logic based vehicle collision avoidance system. They have used CCD camera to capture the image of leading vehicle. To detect object boundary they have proposed HCDFCM algorithm. Fuzzy rules framed based for Degree of Exceeding Safe Distance (DESD) and Safety Coefficient (SC). CMR (Coordinate Mapping Relationship) is proposed to detect the distance between image plane, to measure the height and width of the leading vehicle. The proposed fuzzy inference system consists of three inputs such as relative and absolute velocity and relative distance and the output factors are replaced by safety coefficient. The fuzzy rules proposed are if DESD is low then SC is high, if DESD is medium then SC is medium, if DESD is high then SC is low.

David Fernandez Llorca et al. [16] implemented autonomous fuzzy based steering control for pedestrian collision avoidance. For pedestrian detection the stereo vision based pedestrian detection system has been proposed which provides pedestrian position and relative motion. Computation of TTC plays a major role to avoid collision. If the car to pedestrian TTC (Time to Collision) is below the threshold the two parameters has been considered such as 1.speed of the vehicle 2.lateral displacement. Fuzzy Controller has been designed to steer (Lateral Control) the vehicle automatically if the vehicle and pedestrian in the same lane and if the TTC is below threshold the fuzzy controller automatically steer the vehicle to right or left lane if it is free. The inputs to the fuzzy controller are speed and lateral displacement of the vehicle and the output is steering control.

Huimin Xiong et al. [17] suggested adaptive cruise control which is an enhanced version of conventional cruise control. ACC can able to detect leading vehicle and can able to maintain preset time and speed between the host and leading vehicle. By using ACC the physical and mental resources of the driver will be reduced. ACC radar will not work properly during curved road conditions. ACC may not be suitable for dense driving conditions and drivers who are depending on feedback provided by the ACC may result in negative impact on safety. They have defined the term closing event as a moment when ACC's automatic braking control is activated. The main benefit of ACC is short time headways and reduced overtaking behavior. As per study even though ACC is having some disadvantages it was more effective and it was adapted by most of the drivers. Anyhow for prolonged use the future research in driver adaptation is needed.

Jianqiang Wang et al. [18] proposed longitudinal driving assistance system based ADAS (Advanced Driving Assistance System). They have proposed recursive least square self learning algorithm for determining model parameters collected during manual driving mode. To analyze driver behavior a data collection system was installed in cars to collect signals like speed, acceleration, brake pressure, relative distance etc. the algorithm was validated based on few drivers performances. From that they have taken database for driver behavior analysis and ADAS design. Model parameters of driver characteristics were obtained from RLS method FCW/ FCA algorithms and it was used in manual and automatic driving mode. The result shows that ADAS with self learning approach has favorable driver acceptance.

Seongjin Yim [19] designed preview controller for vehicle rollover prevention. The rollover occurs mainly due to large lateral acceleration by excessive steering at high speed. So to prevent rollover, lateral acceleration, roll over and roll angle should be reduced. The lateral acceleration of the vehicle can be reduced by reducing yaw rate or longitudinal velocity through differential braking or active steering. The bode plots are drawn based on designed preview controllers. In this bode plots the input is steering angle and the outputs are roll angle, lateral acceleration, yaw rate error. The preview controller was simulated using CarSim software. From the simulated results LQ preview and LQSOF preview controller providing better performance than the LQR and LQSOF controllers.

Peng Wang et al. [20] proposed distributed receding horizon control for the forward / backward tracking, regulation and formation with collision avoidance. They have focused on synchronous DRHC. In DRHC the collision avoidance is guaranteed by i) imposing a collision avoidance constraint over the control horizon in the individual optimization problem ii) developing an admissible protection zone. Inside the terminal state region, the auxiliary controller guarantees the collision avoidance by providing backup maneuver. In synchronous DRHC each vehicle does not know the actual trajectories of other vehicles. By substitutions it utilizes the assumed predictive trajectories of other vehicles. By incorporating above constraints the DRHC algorithm was implemented.

JiLiang Luo et al. [21] designed petri net based Programmable Logic Controller (PLC) to avoid collision among the vehicles. A PLC was designed to control an automated guided vehicle system. To avoid deadlock among AGVSs, colored resource oriented PNs were developed. They have implemented software tool to automatically convert closed loop PN into ladder diagram. The sensor, wiring loops and up down counter are the three major elements of AGVS. Sensors are fixed at the guiding path to calculate number of vehicles in that path. When the up down counter receives rising edge on CU terminal the current value of the counter increases by 1. If the rising edge received by CD terminal, current value decreased by 1. When CV (current value) >PV (Preset value) then the output of the counter will be high. Wiring loop is switched on or off to make the vehicle to move forward or stop. The ordinary PN does not depict the switches between on and off states of wiring loop. So, they have designed closed loop PN. Then the closed loop PN is converted into LD which can be run in PLC to avoid collision.

Christoph G. Keller [22] proposed pedestrian collision avoidance which consists of sensing, situation analysis, decision making, and vehicle control. In sensing the image of the pedestrian was sensed using stereo vision sensor and the distance between the vehicle and the pedestrian was estimated using probability mass function. For the detection of moving object 6D vision algorithm is proposed. Then the speed, velocity and position of the pedestrian are given to the situation analysis module. The situation analysis module predicts TTC (Time to Collision), TTB (Time to Brake) and TTS (Time to Steer) which activate automatic collision avoidance by either braking or steering. Decision making is the main module of this system because it is associated with driver's behavior. The driver monitoring algorithm proposed to get signals like brake pedal position, steering angle, lateral & longitudinal acceleration etc to identify the status of the driver. Vehicle control has two main parts to avoid collision such as longitudinal control and lateral control for automatic braking.

Thanh-Trung Han et al. [23] developed measure-theoretic approach to obtain flocking (moving together in large numbers) protocol of mobile robots by means of control design. The flocking protocol was defined as interaction among the agents which results in reduction of the constructed potential function. This protocol yields an alignment i.e. convergence of each agent to the weighted average position of its neighbors while ensuring obstacle avoidance of the network agents. The mathematical functions are implemented for transition equation describing the collective dynamics of mobile robots, from which an auxiliary continuum - model for protocol design is induced, elliptical flocking of mobile robots, control design, styled velocity flocking control.

Alessandro Colombo et al. [24] designed least restrictive supervising algorithm for collision avoidance at intersections. The conflict free control action was achieved by determining maximum controlled invariant set and control actions which keep the system inside this set. Least restrictive set of control actions are determined by the maximum controlled invariant set and the feedback from least restrictive feedback keep the system inside this set. The term verification problem means determining whether the system belongs to maximum controlled invariant set or not. Scheduling literature was proposed to find solution to verification problem.

C. Gomathi et al. [25] reviewed vehicle to vehicle communication protocols for vehicle safety. This paper mainly focused on the review of various communication protocols used in VANET to achieve low latency in delivering warning messages. Sometimes drivers may fail to react in emergency situations. In such case cooperative collision avoidance warn the drivers via warning messages to avoid any potential functions.V2V communication protocols are used to send warning messages to the nearby vehicles during collision. In this paper the performance of three V2V communication protocols are compared and from that they have concluded Vehicular Collision Warning Communication (VCWC) protocol was working better than other protocols.

CONCLUSION

From the literature review of above, the output of all the control modules and algorithms is focused mainly with the collision avoidance system with automation technology. It also mainly convey on some of the major factors and features like driver fatigue condition, object detection, communication among the vehicles during normal and bad weather conditions towards the motto vehicle collision avoidance. Automatic braking system when potential function occurs, keeping the safe distance between the hosts and leading vehicle

automatically control the speed of vehicle which we should be considered while designing a collision avoidance system. This paper will be helpful for the budding research scholars working in the area of vehicle collision avoidance.

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