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IMPLICATION OF MACHINE LEARNING IN AUTOMOBILE FOR ENHANCING PASSENGER AND PEDESTRIAN SAFETY

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Abstract:

Machine learning in automobile for enhancing passenger and pedestrian safety is concerned with developing an algorithm for detection of pedestrian ahead of the vehicle and once a pedestrian is located in a collision prone zone corresponding to the relative distance and relative speed of the vehicle and the pedestrian the time to collision is calculated and a risk factor is determined using Fuzzy controller, a warning signal is generated on the instrument panel to make the driver alert of the oncoming collision. In response to the driver action, the braking is actuated automatically or it supports the driver to avoid hitting the pedestrian and thereby safeguarding the pedestrian as well as occupants of the vehicle.

Keywords:

Autonomous Braking, Collision Avoidance, Fuzzy Controller, Machine Learning, Matlab, Pedestrian Detection, Time to Collision

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I. Introduction

Autonomous vehicle is one of the most emerging topics of this decade of research. One of the main areas of research, in order to achieve successful autonomous vehicle, is safety of passenger and pedestrian. For passenger and pedestrian safety vehicle navigation shall be collision free and most optimum for the autonomous vehicle to maneuver from a source to its destination. An autonomous vehicle is such a person who has no beforehand data about navigation and which needs some algorithm to be used for detection of pedestrian or other obstacle for collision avoidance in order to safeguard pedestrian and the occupants of the vehicle. Pedestrian detection along with autonomous braking does something similar in vehicle with the use of electronic sensors and control system (algorithm). The vehicle uses Camera, Radar, Laser, Light Detection and Ranging (LIDAR), Ultrasound and other sensors for data collection to understand its surroundings. The pedestrian detection ahead of vehicle based on the computer vision is one of the most important functions in automatic driving system. The information of pedestrian is obtained by the camera, which is putted in the moving vehicle. The automobile driving system can extract the pedestrian using the specific algorithm. The pedestrian detection has the great application prospect in auxiliary and pedestrian safety. So, the pedestrian detection become the research hot spot. However, the road traffic safety has become a serious social problem. Research shows that more than 90% of fatal traffic accidents are caused by the driver's fault [1]. At present, the application of the passive safety technology (safety belt and airbag) reduces the injury to passengers, but the root cause of the accident is not resolved [2]. Active safety technology has become more mature, early warning and driving intervention can be given to the car by the automatic braking system, in order to improve the driving safety level and avoid accidents, thereby safeguarding pedestrian as well as passengers.

II. Driver Assistance System

2.1 Driver's Capability and Task Demand.

The difficulty of a driving task is determined by the interaction between driver capability andtask demand. The driver adjusts the task difficulty, which is calculated by subtracting thecapability from the task demand. The task-capability interface model suggests the concept oftask difficulty controls in driving [4]. When task demand exceeds driver capability, taskdifficulty is so high that the driver cannot complete the driving task. This condition may leadto a collision or a loss of control. When capability exceeds demand, the task is easy and thedriver successfully accomplishes it. Figure 2.1 presents the concept of task difficulty adjustment.The driver's capability is maintained and the task demand is decreased in order to maintainthe driver's capability above the task demand.The task demand and the driver's capability are influenced by several factors.

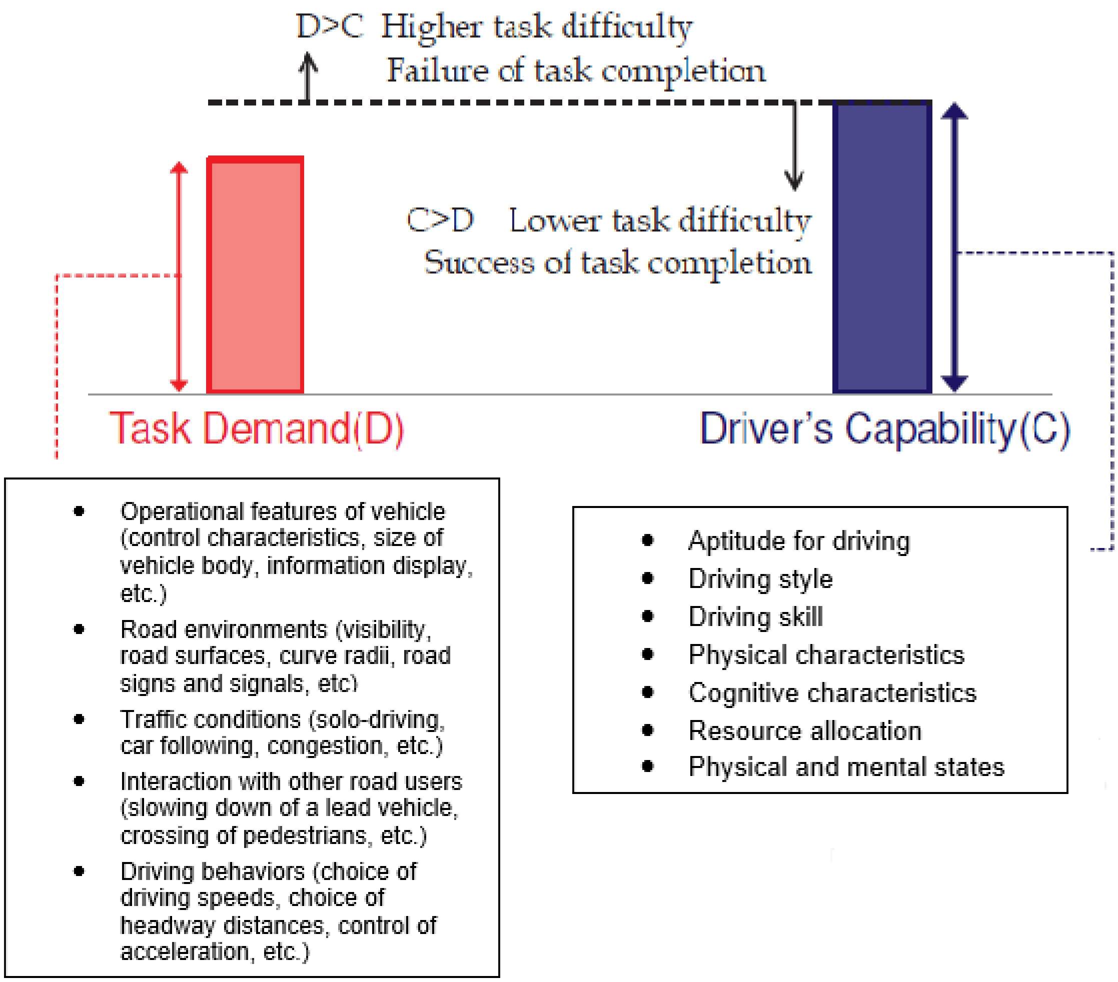

Figure 2.1: Interaction between Task Demand and Driver's Capability

The task demand is determined by the operational features of the vehicle, environmental factors including the road environment and traffic conditions, and interactions with other road users. Different passenger cars have different operational features. The road environment includes visibility and road surfaces changed by the weather, curve radii, and road signs and signals. Traffic conditions differ with the number of vehicles, pedestrians, and bicycles near the driver's vehicle and the movements of other road users influence task demand. Task demand is also influenced by driving behavior, including control of driving speed, headway distance, and acceleration. For example, shorter headway distance leads to higher task demand and requireshigher driver capability of paying attention to the movement of the lead vehicle. In contrast, greater headway distance leads to lower task demand thus, the possibility of rear-end collision is lower even when the driver does not allocate many resources to the driving task. The important point in the task-capability interface model is that the driving task demand can be controlled by the driver's own driving behavior. The driver's capability is constrained by aptitude for driving, driving style, driving skill, and physical and cognitive characteristics (e.g., physical reach, reaction time, and information processing capacity). It is also constrained by resource allocation. More concentration on the driving task enhances the driver's capability, and distracted driving decreases the driver's capability. The driver's physical and mental states, including fatigue and drowsiness, also impact the driver's capability and can vary at different times while driving.

2.2 Conventional Driving Assistance System

The typical driving area has some range because both the task demand andthe driver's temporary capability changes according to driving conditions. For example, taskdemand increases when a lead vehicle suddenly decelerates and the headway distancedecreases while following the lead vehicle. However, task demand decreases when driving

with no other vehicles around the driver's vehicle on a straight road with wide traffic lanes.A driver allocates more resources when changing traffic lanes or overtaking a vehicle, leadingto higher driver capability. When a driver glances at objects irrelevant to the driving task, thedriver's temporary capability decreases.

Conventional driver-assistance systems that are now installed in passenger cars assist driverswhen the task demand suddenly increases and/or the driver's capability decreases. Thesensors installed in the vehicle detect situations in which task demand suddenly increases dueto an immediate change in traffic conditions (e.g., sudden deceleration of a lead vehicle or atraffic jam after a sharp curve) [5]. Present work promotes driving with lower task demand.

This new system may contribute in reducing driving risk, the possibility of entering the area where task demand is above drivercapability, which potentially underlies normal drives.

III. Algorithm

The algorithm presented in this chapter basically explains the logic used for pedestrian detection Basic things that this algorithm takes care of are:

a) Locate the pedestrian ahead of the vehicle

b) Calculates the time to collision

c) Generates a warning signal for the driver

d) Actuates the brakes automatically corresponding to the driver response and time to collision with pedestrian.

3.1 Pedestrian Detection

A RADAR and Camera is used in junction for the detection of pedestrian ahead of the vehicle. The RADAR takes care of the pedestrian which are distant away from the vehicle whereas camera is sensing a short distant located pedestrian.

For pedestrian detection the platform which is being used for proposed work is Matlab. Where a Faster RCNN is used to locate the pedestrian ahead of the vehicle. Faster R-CNN utilizes two networks: a region proposal network (RPN) for generating region proposals and a network utilizing these proposals for detection of object (pedestrian). The main difference which it has with respect to Fast R-CNN is that it utilizes selective search to generate region proposals. The time cost of generating region proposals is much smaller in RPN than selective search, when RPN shares the most computation with the object detection network. Briefly RPN ranks region boxes called anchors and proposes the one most likely containing the object (pedestrian). The architecture is shown in figure 3.1. once the pedestrian is detected using the mentioned architecture of Faster R-CNN the next stage is to determine the time to collision (TTC) of the car with pedestrian and determining the risk factor.

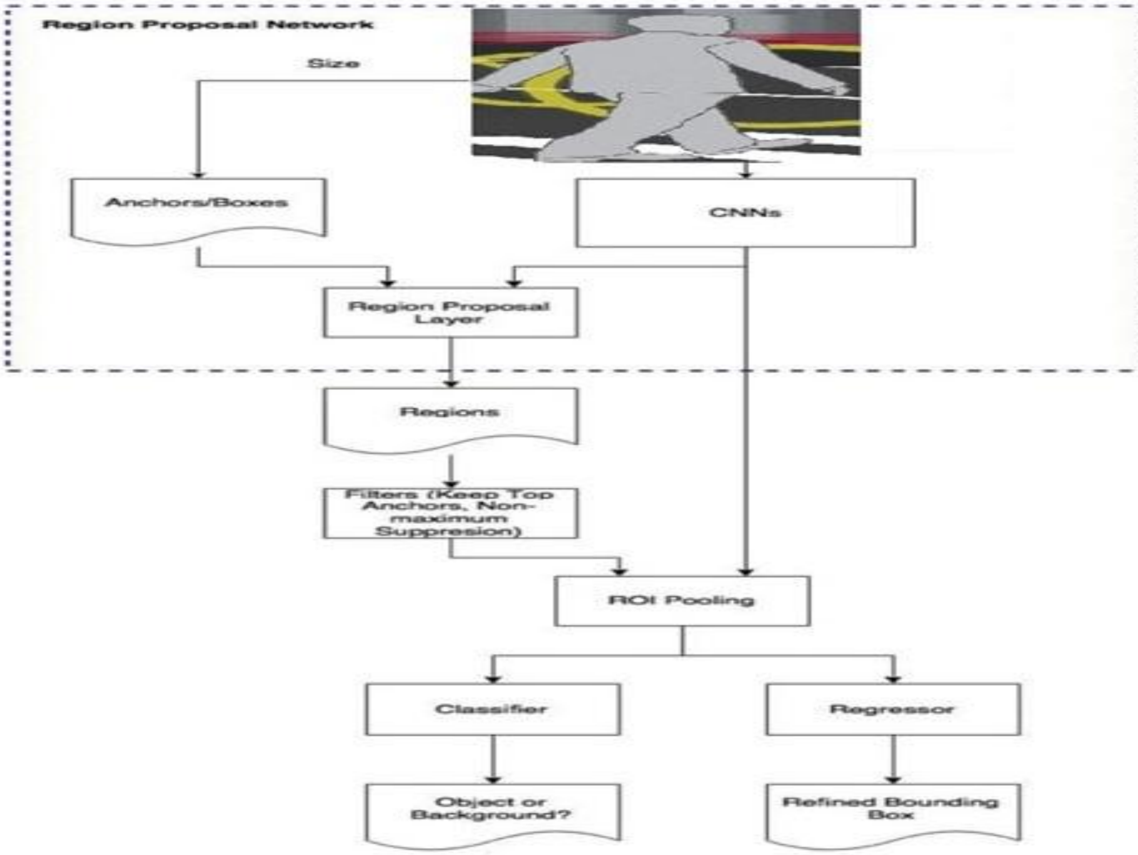

Figure 3.1 Architecture of Faster R-CNN

Figure 3.2: Pedestrian Detection Using Matlab

3.2 Calculation of time to collision

To determine a collision risk, the instantaneous time to collision (TTC) is calculated. TTC is the ratio of instantaneous range to range rate. Figure 3.3 shows a schematic of vehicle position and the speed of the striking vehicle in a lead pedestrian stopped collision. When the driver should press the brake pedal in order to avoid the collision, the vehicle is travelling at a speed of $V_{1,0}$ and is at a distance of L_0 from the pedestrian. Because the pedestrian is in stopped condition, the range rate is equal to the speed of the vehicle

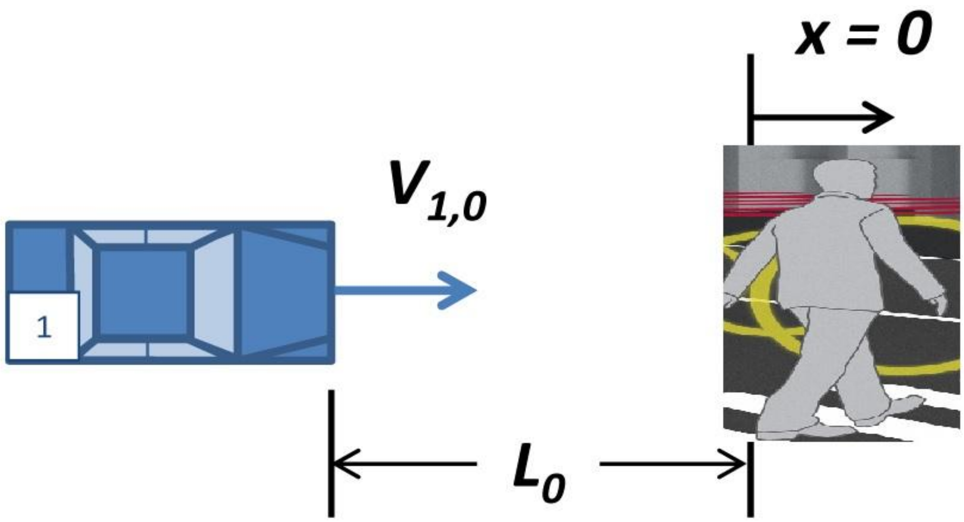

Figure 3.3: Position of Pedestrian Corresponding to the Striking Vehicle

The TTC at pressing of brake pedal is thus,

$TTC = \frac{L_0}{V_{1,0}}$ ………………….(3.1)

The velocity in equation 3.1 is evaluated as the vehicle speed at the time when the braking should begin. The initial range at that same point of time is estimated by assuming a constant vehicle deceleration, "a", during the braking time. For constant braking deceleration, the position of vehicle, x, is

$x = -L_0 + V_{1,0}t - \frac{1}{2}at^2$ …………………….(3.2)

Where t is the time after braking has started and a is the magnitude of deceleration. The delay of braking system actuation is assumed to be negligible. Substituting equation 3.1 in equation 3.2 at the time prior to the impact when braking should begin, t_s, yields an expression for time to collision (TTC) as

$TTC = t_s - \frac{1}{2V_{1,0}}at_s^2$ ………………….(3.3)

On prediction of time to collision (TTC) of subject vehicle with pedestrian the next step is to determine the risk factor.

The risk factor "E" is evaluated using a fuzzy controller in Matlab. Which is based on the two input and one output. The input being relative distance and relative speed of the vehicle corresponding to the pedestrian location and output being the risk factor "E".Both the input and output are described by six fuzzy linguistic values which are (mf1, mf2, mf3, mf4, mf5, mf6). Basic range of relativedistance, relative speed and the risk factor are [0,125] m, [0,40] m/s and [0,1] respectively. Their rule-scaling factors are separately 1/25,1/8 and 1/5. Therefore, fuzzy fields of the input and output are both [0,5]. The membership functions of linguistic fuzzy subset are well distributed in the form of triangle function, and the solution of the fuzzy subset is to use the centroid. Fuzzy rules have important influence on the risk assessment.Vehicle's braking capability and driver's behavior should be considered as well, which helps to make the principles of fuzzy rules. Thus, the rule is that considering the braking ability of the vehicle itself and the braking distance under the condition of having the different speed, if keeping the relative speed, there will get more risk with a closer distance but less risk with a longer distance; if keeping the relative distance, there will get more risk with a higher speed but less risk with a lower speed.

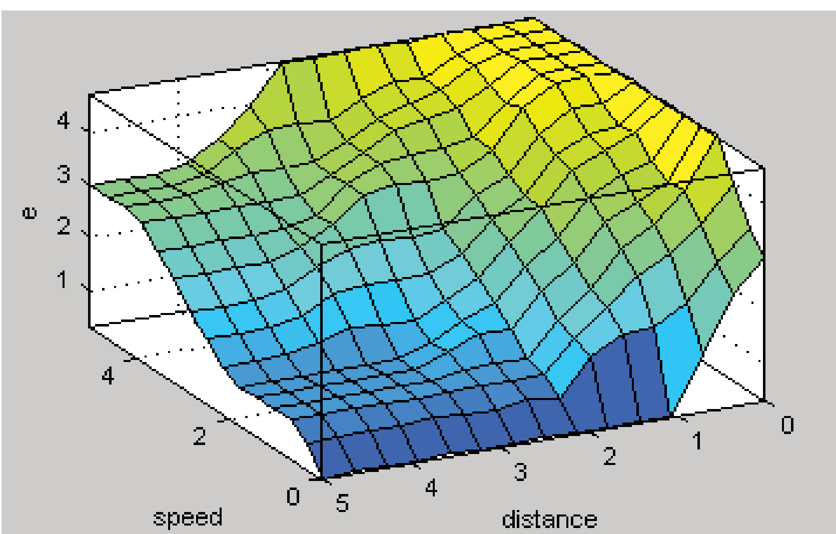

Figure 3.4: Fuzzy Surface

Riskiness	$0<E<0.4$	$0.4<E<0.5$	$0.5<E<0.6$	$0.6<E<0.7$	$0.7<E<1$
Risk Status	Safe	Safety Tips	Severe	Dangerous	Extremely Dangerous
Warning	No action	Light	Obvious	50% Brake	Full Load Brake

Table 1: Riskiness Value and Corresponding Warning

Where “E” denotes the risk factor

3.3Autonomous Braking

Once the pedestrian is located ahead of the vehicle and in the region of a prominent collision with the subject vehicle, depending upon the predicted time to collision (TTC) and associated risk factor “E” with the pedestrian the braking system is actuated autonomously or a warning alarm is generated to alert the driver.

In the previous section, the risk factor “E” is obtained through the time to collision directly indicates the risk of collision accident. Therefore, it can be taken as an effective criterion for the automatic brake system to generate early warning and intervention of controlling.

When Pedestrian appear at front, driver do not brake, and risk factor is over a particular threshold, the system will take the brake action automatically in order to avoid accidents. Active brake should not be used frequently because it leads to frequent nods of the vehicle. Thus, once the active brake is used, the vehicle is expected to move with a constant deceleration until it stops. The risk factor is divided into five areas in Table 1, which is safe area, light warning area, severe warning area, 50% active brake area, and fullload brake area. Studies suggest that compared to the severe warning mixed with sound and light, the early warning will bring the driver greater response and wrong reaction.So, the first-degree warning should use light warning, and the second-degree warning should take both light and sound alarm [13]. On the general dangerous area, the car should be braked with a low speed in order to make passengers comfortable. However, on the extremely dangerous area, compared to the comfortable status, safety is the most important thing and full-load brake action must be actuated to ensure passenger’s and pedestrian safety.

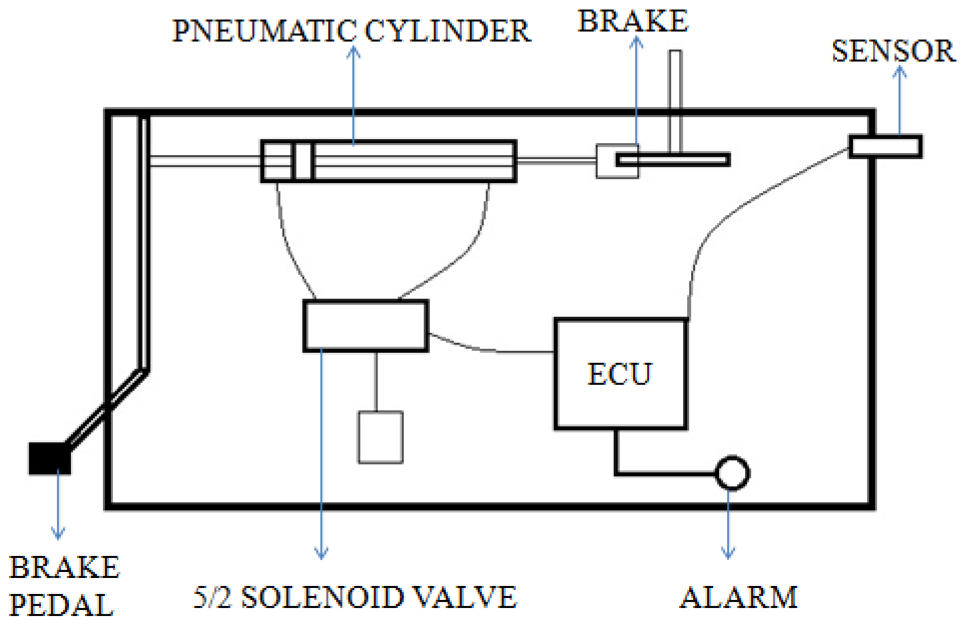

Figure 3.5: Autonomous Braking System

3.3.1 Procedure of Braking:

1. The RADAR and Camera, which will sense the pedestrian in front of the vehicle and will give continuous output while vehicle is in motion. In present work if pedestrian comes in contact with the sensors it will generate an output to the ECU.
2. Depending upon sensor output to ECU the TTC and risk factor "E" is determined using the Fuzzy controller.
3. Thereafter, ECU will generate an audio/ visual warning signal to alert the driver about the situation if driver responses corresponding to the warning signal than the action will be completed through driver response
4. If the driver doesn't respond to this warning signal that means no action is taken then ECU will send the signal to the braking system.
5. Thus, Stroke of Hydraulic cylinder will start and lead to Auto Forcing the Brake Paddle to engage and lead to stopping the Vehicle.

IV. Result

The proposed work for enhancing the passenger and pedestrian safety using machine learning can safeguard the road population as well as the occupants of the subject vehicle by locating a pedestrian ahead of the vehicle and determining an impending collision using the RADAR sensor and Camera mounted on front windshield of the subject car. The pedestrian detection algorithm used for determining the location of pedestrian is Faster R-CNN as it reduces the computation time. On locating the pedestrian, the time to collision (TTC) is calculated which will thereby determine the risk factor "E" using Fuzzy Logic.Based on the value of "E" a warning signal is generated to alert the driver or the car brakes are automatically actuated when an imminent collision is identified.

V. Conclusion

This paper presents a method of detection of pedestrian using Machine Learning and also provides a means to evaluate the risk factor "E" using Fuzzy Logic by utilizing relative distance and relative speed of the car and pedestrian and clearly knowing the driver's driving habits and experience the fuzzy rules are formed. Potential benefits of implementing machine learning in automobile for enhancing pedestrian and passenger safety is greatest in reducing the pedestrian crashes. Based on passengers feeling about the accidents, collision avoidance strategy will be actively applied to avoid the occurrence of accidents, and also improve automobile safety performance.

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