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Development of a Vehicle Door Anti-Collision System with Pressure and Radar Sensors for Enhanced Road Safety

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Abstract: To address the issue of door-opening collisions, this paper proposes a door-opening anti-collision system that incorporates a door-opening pressure transducer and a vehicle-mounted radar sensor as its primary components. The system evaluates the potential for collisions by integrating data from both in-vehicle occupants and external vehicles. Utilizing voice alerts, radar video displays, and an automatic locking mechanism, it provides warnings and protective measures in hazardous situations. The vehicle's CPU processes this information, considering the braking conditions, door switch sensor, and the time it takes for an approaching vehicle to reach the current vehicle at its speed, to determine the necessity of an alarm. This system effectively safeguards pedestrians and reduces the risk of injury and property damage caused by door-related accidents.

Keywords: Anti-collision system, car door.

1. Introduction

In recent years, with the improvement of people's living standards, private cars have become the main means of transportation for many people. According to data released by the Traffic Management Bureau of the Ministry of Public Security, private cars (private small passenger cars) continue to grow rapidly. In 2018, the number of possessions reached 189 million, an average annual increase of 19.52 million in the past five years. There is a certain safety hazard in the process of driving the driver to open the door. Since the driver does not know when there is a car at the time of opening the door, the door opening speed is too fast, and the rear vehicle (battery car, bicycle, etc.) cannot be evaded in time to avoid the sudden accident. May cause casualties. The accident situation is shown in Figure 1. Here are three typical car door knocking events.

Case 1

In December 2018, Quanmou drove Zhang to go out to work, and Zhang sat in the position behind the driver. After moving to the destination, Quanmou temporarily parked on the non- motorized road. Zhang did not observe the rear situation and directly opened the door. As a result, the door knocked down Guo, who was driving the electric car behind him. Guo was injured on the spot and died after being rescued by the hospital.

Case 2

On July 11, 2018, when the driver of the network car, Hu Mou, drove the car near a bus stop, the passenger in the car opened the right back door and crashed into the car riding the electric bicycle. The person was injured in the car and fell to the ground.

Case 3

On November , 2017, Zhang drove a "BMW" brand small car. After parking outside a jewelry store on Xinping East Road in Pinggu District, when he opened the door and got off, it happened that Yang

drove the electric bicycle from north to south. The two cars collided, and Yang fell to the ground and died after being rescued by the hospital.



Figure 1. Car parking door accident

According to the Regulations on the Implementation of the Road Traffic Safety Law, if a motorized vehicle temporarily stops on the road, it shall comply with the fact that the vehicle shall not open the door and the upper and lower personnel before the vehicle is stopped. The door of the switch shall not obstruct the passage of other vehicles and pedestrians[1]. Before opening the door, carefully observe the surrounding areas and develop good habits to effectively avoid the occurrence of tragedy. Although there are relevant regulations, the people inside the car will forget to observe whether there is a rear car before getting off the bus, whichcauses such accidents to occur frequently.

In view of the above phenomenon, the design of this paper can sense whether the inside of the vehicle has a door opening condition and a system to identify whether there is a vehicle passing through a certain range. The system can remind the insiders of the car to observe the rear car before opening the door, and also can warn the rear vehicle, and can issue an alarm and lock the door when identifying the incoming car.

2. System Function Analysis

2.1. The Function of Judging the Door Opening Situation of the Inside of the Cars

In the vehicle door collision avoidance system designed , the door switch sensor can transmit signals to the processing circuit in combination with the brake condition of the car, the use of the seat belt inside the car, and the situation in which the person inside the vehicle touches the door switch. At the same time, the time threshold for the process of the person inside the vehicle touching the door switch to open the door is designed.

2.2. Out-of-vehicle Sensing Function

After the vehicle brakes, the external radar sensing system is activated, and the vehicles that may have a door opening collision are judged according to the sensing range, the vehicle speed and the time threshold, and the dangerous vehicle information is screened.

2.3. Security Alert Function

According to the information obtained by the outside system, the position of the dangerous vehicle can be displayed in the in-vehicle radar display system, and the person inside the vehicle can be prompted to come to the rear.

2.4. Automatic Lock Function

At the same time as the safety alarm is issued, the door can be automatically locked, or when the door is opened, the door is locked, so that the door can only be closed and cannot be opened further.

3. System Structure Design

The system structure design is shown in Figure 2. The system combines the door switch sensor and the radar sensor as the core, integrates the information inside and outside the vehicle, and screens the rear vehicle that may cause the door opening accident to be displayed on the display screen, and the joint alarm system. The automatic locking system with the door ensures the personal safety and property safety of the inside and outside of the vehicle.

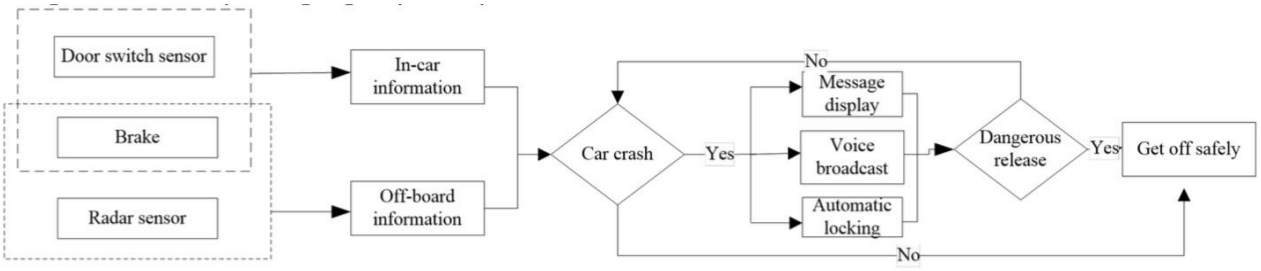


Figure 2. Structure of the car door collision avoidance system

4. System Function Realization

4.1. Door Switch Pressure Sensor

A pressure sensor is a device or device that senses a pressure signal and converts the pressure signal into a usable output electrical signal according to a certain law. The pressure sensor usually consists of a pressure sensitive component and a signal processing unit. Here we use a strain gauge pressure sensor. The internal structure is mainly composed of a base material, a metal strain gauge, an insulating protective sheet and a lead wire. Here, we combine the pressure sensor with the door switch. When the passenger in the car needs to open the door, the contact between the hand and the door switch will cause the metal strain gauge to deform, resulting in a change in the resistance value. Since the strain gauges generated by the strain gauges are usually small when subjected to force, we amplify the signals by subsequent processing and transmit them to the processing circuit (CPU) [2-3].

The working principle of the metal resistance strain gauge is a phenomenon in which the strain resistance adsorbed on the base material changes with the mechanical deformation. The resistance value of the metal conductor can be expressed by the following formula 1:

$$R = \frac{\rho l}{S} \tag{1}$$

Where: ρ—resistivity of metal conductor (Ω•cm2/m)
S—cross-sectional area of the conductor (cm2) l—the length of the conductor (m)

4.2. Vehicle Radar Sensor

This design uses millimeter-wave radar sensors to collect information on dynamic targets around the vehicle, including distance and speed. Millimeter wave radar mainly uses the Doppler effect to measure the speed of not listening to the distance target. Doppler effect refers to the difference between the transmitting frequency and the frequency of the reflected frequency and the reflected frequency, and then the frequency difference pool can be measured to measure the moving speed of the target relative to the radar[4-5]. The obtained distance information is added to the length of the vehicle body to obtain the distance D and the speed information for calculation, and the time required for the rear vehicle to the door is obtained. If it is less than 3S, the danger is considered to occur, and the alarm system is activated.

(1) Principle of Ranging

The radar frequency modulator transmits a continuous wave signal through the antenna. After the transmitted signal meets the target, the reflected signal of the target generates an echo signal. The transmitted signal has the same shape as the echo signal, but there is a difference in time[4-5]. The ranging formula is Equation 2.

$$R = \frac{cT}{8\Delta F} * (f_{b-} + f_{b+}) \tag{2}$$

Where: R—the distance of the target object
c—speed of light
T—transmit signal period
f b+—the frequency of the IF signal during the rising phase of the signal f
b+—and the frequency of the falling phase f b-

(2) Principle of Speed Measurement

When there is relative motion between the target and the radar signal transmission source, in addition to the time difference between the echo signal reflected by the target and the transmitted signal, a Doppler shift fd is generated between the frequency of the echo signal and the transmitted signal[4-5].

The expression for speed v is as follows:

$$v = \frac{c}{4f} * (f_{b-} + f_{b+}) \tag{3}$$

4.3. Voice Broadcast

The design of the voice prompt module is mainly based on the own voice module in the vehicle system. The voice module of the vehicle is mainly realized by the single chip microcomputer. The voice chip generally has automatic gain control, microphone preamplifier, speaker, oscillator and memory. Etc[6]. You can record “there is a car in the rear, do not open the door” in the recorded content. This information is used as the voice prompt information designed by the car door collision avoidance system. When the alarm system is activated, the voice

broadcast module is triggered to remind the vehicle personnel to pass the vehicle behind. Do not open the door to get off safely.

4.4. Information Display

In the information display module, it is mainly combined with the radar display system. When the radar detects the dynamic target and judges that it needs to be alarmed, the system will display the color of the detected target, that is, display the vehicle that may cause an accident within a certain range around the vehicle to display on the display to help the driver obtain Information on dangerous vehicles[7]. The reliability of this system design can be improved by the design shown. Taking the traveler as the research object, there is a tendency to be irritated without knowing the specific situation. By showing the specific dangerous thing, it is possible to reduce the radical choice of the person inside the vehicle, and the individual can judge the safety and get off the vehicle. Second, the displayed target may be in the blind spot of the people in the car. This design makes it possible to visually see the dangerous objects in the blind spot.

4.5. Automatic Locking

The door automatic locking device is mainly improved by using the existing vehicle inside the vehicle to get off the vehicle, and the door is automatically locked. The specific operation circuit can be known from the literature 8. The passengers in the car get off the bus, which is similar to the situation in the car that is ready to get off. Add a parallel signal control here. It means that if W=1, that is, the alarm system is activated, the automatically locked device line is a passage, thereby starting the automatic locking device, thereby warning the vehicle personnel not to open the door to avoid danger.

4.6. Information Processing

The specific information processing is shown in Figure 3, and the data of the above two aspects are processed by the CPU of the vehicle. The signal sensed by the door switch sensor is used as the start signal for the entire design run. The following assumptions are made in this design:

(1) Whether the vehicle is braking is necessary, whether the vehicle brake is set to S, if it is not braked, it is 1 and the brake is 0;

(2) Assume that the door sensor transmits information as C, if there is signal transmission, it is 1, and the untransmitted information is 0;

(3) The alarm system is represented by W. If S=1, C=1, D/V<3, then W=1, the alarm mechanism is triggered.

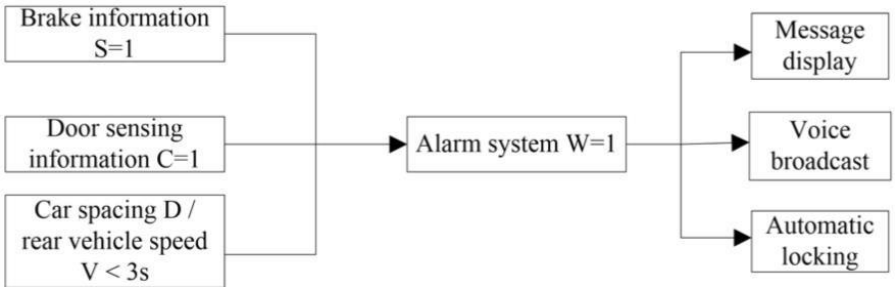


Figure 3. Information processing judgment flow chart

5. Conclusion

Based on the existing car door collision avoidance system developed by the car door collision accident, this paper integrates the information of the inside of the vehicle and the information

of the vehicle outside the vehicle, predicts whether a collision accident occurs, and provides corresponding warning measures and preventive measures.

The information in the car is mainly based on the vehicle brake information, seat belt use information and door switch sensor information to analyze the door opening situation of the vehicle. At the same time, the radar sensor is activated at the same time as the vehicle brakes, and the information outside the vehicle is integrated, and the pre-judgment is made according to the distance and speed of the rear vehicle. Information inside and outside the vehicle is sent to the vehicle CPU for analysis to determine whether it is necessary to activate the alarm system. After the alarm system is activated, the voice broadcast will be activated in the car. The radar display system displays the information of the location of the dangerous vehicle. At the same time, the automatic door lock function is enabled, so that the passengers inside the vehicle cannot open the door, or when the door is opened, the push cannot be further pushed. Drive the door and only close it.

The system is designed to reduce the number of casualties caused by the opening of the car, to ensure the safety of passengers getting on and off the car and the safe passage of the rear vehicles.

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