Study on Vehicle Anti-collision Warning System Based on Radar Ranging

JIANG Libiao, LIU Yonghua, Gu Fangde
(Harbin Institute of Technology, Shandong Weihai, 264209, China)

Abstract: Vehicle anti-collision warning system is an important component of the intelligent vehicle system. It can real-time acquire, express and Collaborative solve the dynamic environment information and judge vehicle's status to alarm. So the collision incidences are reduced. The measurement of speed-distance is the key to vehicle anti-collision system. This article firstly analyses the principle of this system and then compares the advantages and disadvantages of several vehicle object-detecting techniques at home and abroad. A radar ranging warning system are built and the core module's of composition and the basic principles are analysed. So that, the system can accurately detect the speed and distance close to other car. The timely issuance of sound-light and voice alarm signals remind drivers to pay attention to avoid rear-end accidents.
Keywords: Anti-collision warning, Vehicle object-detecting technique, Radar ranging, Traffic safety

1 Introduction

As the cars grows and speed improves, especially in bad weather and drive fatigue and many other factors, lead to a variety of unexpected accidents at any time. Once the accident occurs on the highway traffic, there will be similar to the "domino" effect. Road safety gains more and more attention. Passive safety systems can only reduce the extent of the accident, it can not effectively prevent the occurrence of accidents, active safety systems would be a trend.

Vehicle anti-collision warning system(AWS) can be real-time monitoring the environmental conditions of vehicles driving front, left, right and rear side, display in the real-time LCD; Meantime, predicting the probable risk of accidents, alarming by sound, light, LCD display, etc. alert the driver attention and to take effective measures in time; After entering the danger area, if the pilot did not take timely and effective measures, the system will immediately control the throttle through the implementing agency, steering or braking institutions so that the distance between vehicles maintain the set minimum collision distance at least.

This paper mainly analyze the principles of vehicle collision avoidance warning system, at the same time build radar ranging speed system, enabling the system to detect the critical vehicle speed and distance accurately, take the initiative to avoid accidents.

2 Overview Of the Vehicle Anti-collision Warning System

Vehicle anti-collision warning system, is a kind of system that can predict risk of collision and alert driver prior to collision occurs ,which can prevent traffic accidents, it`s known as the third eye never stops. AWS is functioned by dynamic video camera technology and computer image processing technology, it assembles 4 different types as a whole.

(1) Front collision warning:Alarm before the collision risk, remind to the brakes; at the same time, taillights flash continuously, pay attention to the back car to avoid tailgating;

(2) Lane departure warning: The system is alarmed before lane departure took place unconsciously, to draw attention to keep the original lane for safe driving, this feature is especially suitable for long-distance drivers and fatigue driving;

(3) Vehicle distance control Warning: Always allow the driver maintain a safe driving distance, and it can alarm when the distance is too close;

(4) Side collision warning: When there is a car in adjacent Road, if the driver began to change Road, alarm in the way of image and sound warning, control vehicles rotating brake force generated by the wheel brake system, to avoid the traffic adjacent.

2.1 Basic Principles of AWS

Vehicle anti-collision warning system makes use of modern information technology, sensor technology to extend the driver's perceived capacity to access external information to the driver, combined with state of the car to identify target movement status, the relative velocity, relative movement direction, to determine the current data applicable to the model, then depending on the weather

Road conditions determine the critical level of predicted risk of accidents. AWS has environmental detection and identification functions, forecasting accidents and danger judgments, automation and execution capabilities, distance detection go through the obstacle, control strategy selection, auto throttle, brake and steering control systems, etc. achieving warning and control functions. when emergency, issued by the vehicle microprocessor control commands, auto-control measures, keeping the car away from danger, to ensure vehicle safety. AWS`s working principle in Figure 1.

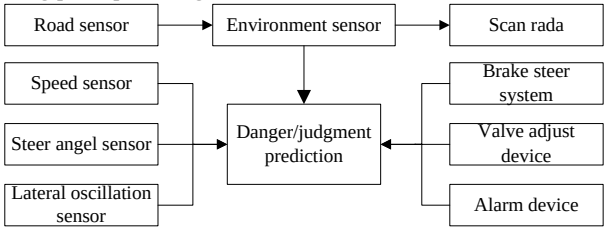

Figure 1 principle of automotive anti-collision warning system

The system helps to maintain a safe distance from the vehicle in front, when the distance warning system is activated, the driver can pre-set their own time interval with the previous car, when car running, the system detected the time interval between your car and the car in front lower than your settings, warning issued through the front windshield, along with warning bell, if the driver still has not taken any safety measures, the system will take the initiative to help you brake.

2.2 The Constitution Of Vehicle Anti-collision Warning System

Smart anti-collision system is the forefront of automotive active safety issues, its typical structure, including environmental recognition system, safety forecasting system, warning control system, vehicle control part three parts, as shown in Figure 2.

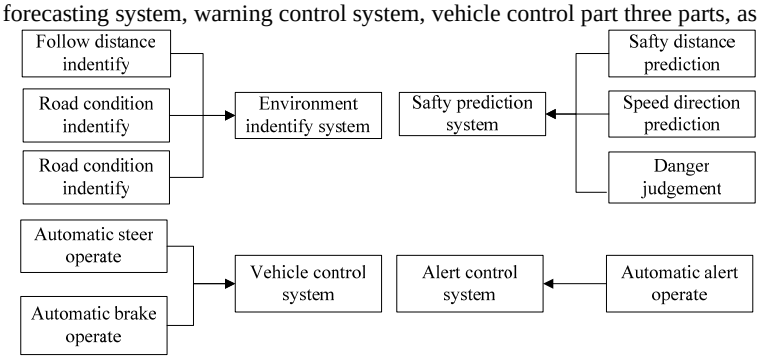

Figure 2 The constitution of vehicle anti-collision warning system

(1) Environment recognition system, which is information acquisition section of the system. vehicle active safety is affected by the road motivation, vehicles and road conditions and other information. System configuration has the sensors which are able to identify external information (such as obstacles in front of the moving direction, speed, the vehicle's own speed, vehicles and the distance between the front of obstacles, etc.). Currently the main senors used to identify the vehicle outside is ultrasonic, laser, millimeter radar, infrared, CCD cameras and so on.

(2) Safety prediction system, which is information processing section of the system. It is the nerve center of intelligent braking system, by processing the information from the outside world to judge and make quick and accurate response.

(3) The warning control system, which is information response section of the system. It is issued to alert distracted drivers. Driver alert control system is consist of a camera, a number of sensors and a control unit. Camera is set between the windshield and the inside rear mirror, continuously measure vehicle and the distance between the lane mark and car; sensors take the car's movement; control unit storing the information and calculates whether there is risk of loss of control. If the results of the assessment is a high-risk, alert the driver by the sound signal.

(4) Vehicle control section, which is an intelligent braking system. It is the last car safe driving safeguard, mainly composed of high-speed solenoid valves and brakes. If the computer judge there would be a collision by the speed and distance measurement, that is, the distance between vehicles and obstacles less than or close to the limit of safe distance, the safety / risk prediction system will send a emergency brake signal to the high-speed solenoid valve.

3 Several Vehicle Target Detection Technique

Automobile collision avoidance system is based on speed and distance measurement. In a variety of environmental conditions, measure the front vehicle speed and distance accurately is the key to system design. At present, the methods of measuring the distance between the cars and speed include three types which are ultrasonic, laser and microwave radar method.

(1) Ultrasonic measuring

The basic principles of ultrasonic backing radar is the use of ultra-wave, and then reflected back to the front of ultrasound to determine whether there are obstacles, and its distance, size, direction and shape and so on. The current backing radar mainly used to judge the distance from obstacles and make tips. characterized by rain, fog, snow penetrating ability, it can work in bad weather, the system is easy to manipulate and low cost. Its main drawback is that reaction time would be a little longer, measurement error、divergence angle is large, low resolution, attenuate fast, effective measurement of the distance is short, commonly used in the rear backing radar.

(2) Laser measuring

Pulsed laser main has two methods of ranging and scanning, laser measuring system is responded rapidly, effective measure distances large, high resolution, small error, etc. In recent years, in the field of automotive crash gain more and more attention. As the laser lens prone to dust, rain and snow, wind and sand erosion and pollution, which may affect its work performance.

(3) Icrowave radar measuring

Microwave radar measuring is make use of electromagnetic waves reflections from the target back to the at finding the target and its location, By analyzing, alarm according to the risk of objectives, control vehicle`s speed until braking automatically.

Microwave radar, compared with the other two methods has significant advantages, because of its high operating frequency, short wave length, which can effectively reduce the beam angle, reduce the antenna size, particularly suitable in harsh weather conditions. Application of microwave radar measuring, should prevent interference between the radar as well as other electromagnetic communication systems. Benz.AG Germany and Nissan Motor Co, Ltd have applied ADC' millimeter radar in the development of Collision Avoidance System and Automatic Cruise Control System.

4 Radar Speed System Implementation

4.1 The Structure of FMCW System

There are two main kings of microwave radar vehicle collision avoidance system: Pulse Doppler system and the frequency-modulated continuous wave (FMCW) system. Frequency Modulated Continuous Wave Radar`s structure is simple, appropriate to measure close targets, so as the vehicle anti-collision radar is currently a popular choice. Its basic principle can be described as the signal instantaneous frequency changes as time that is linear transformation, when there is a single target echo, the emission signal and the reflected signals will be mixed, which is contained target relative distance and relative velocity information.

When the vehicle is moving, the radar beam send narrow frequency-modulated continuous wave signal to the front, when the

transmit signal encountered target, it is reflected back to the same antenna, after mixed signal amplification is processed, beat signal can be used to indicate the distance between the radar and target, the corresponding pulse signal obtained by the microprocessor to handle calculations of the distance values, and then rely on difference frequency signal in accordance with the relative velocity, calculate the relative speed between target and radar; the above two physical quantities is sent by microprocessor into a dangerous digital time function model, it can calculate the risk of time; when the degree of danger to achieve a variety of different levels, output alarm signal or the respective vehicle control circuit to control the speed or braking.

Radar send high repetition cycle pulse to a certain space, when the encounter a fixed target, the reflected waves will be reflected back with the launch of high-frequency pulse a lag time lag ΔT , $\Delta T = 2R/C$, Mixer output signal is

$$f = [B/(T/2)](2R/C) = (4B/TC)R \quad (1)$$

So: T is triangular wave cycle; C is electromagnetic wave propagation speed; B is the bandwidth launching of the signal; R is the distance between target and radar.

Figure 3 is the principle of radar measurement.

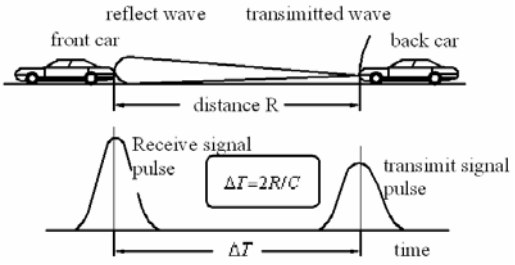

Figure 3 the principle of radar measurement

For the moving target, the reflecting signal contains the Doppler frequency $f^{'}=2v/\lambda$, λ is transmit signal wavelength, v is the target velocity. in the modulated signal increase segment $f_{+}=(4B/TC)R-f^{'}$; in descending modulation signal $f_{-}=(4B/TC)R+f^{'}$, will add f_{+} and f_{-} subtract, respectively are:

$$R=\frac{(f_{+}+f_{-})TC}{8B} \qquad v=\frac{C}{4f_0}(f_{-}-f_{+}) \quad (2)$$

Where: f_0 is transmit signal center frequency. As can be seen from the above formula, as long as real-time calculations f_{+} , f_{-} out, you can easily calculate the distance and speed.

4.2 Radar Measuring Device Structure

Radar Measuring device structure is shown in Figure 4. Including launch device, receive device the radar calculate the distance, signal processing circuit, display device and the speed sensors and other accessories.

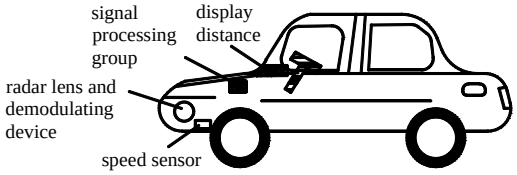

Figure 4 radar measuring on-board status

(1) The alarm module is MCU-controlled light-emitting diodes and the speaker. When the distance closer than the safe one, the MCU send signal and control the light-emitting diode flashes, with a voice alarm.

(2) Transmitting and receiving antennas can be installed on the vehicle front-end, send transmit signals to the front, and receive reflected signals.

(3) RF transceiver front-end is the core component of radar system, which is responsible for signal modulation, transmitting and receiving RF signals and receiving signal demodulation.

(4) The automatic analysis of information processing module, calculate the distance among the vehicles in front and the relative speed, and prevent the turning errors from measurement the vehicle of approaching lane.

4.3 The Technical Requirements For Automotive Radar Systems

Automotive radar system's technical requirements include requirements from the detection range, requirements of angle detection range, the accuracy requirements of temperature measurement and scope of application, anti-seismic and anti-jamming and other reliability requirements. Vehicle detection range of radar systems indicate as shown.

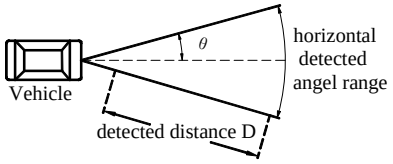

Figure 5 Vehicle detection range of radar systems

D is the distance measurement range; θ s the level of half the angle of the detection range.

Among them, $v_{\min}$ and $v_{\max}$ that automotive collision avoidance system is suitable for the minimum and maximum speed, t the distance value for the workshop. Road traffic from Chinese actual situation, between the range of values t=1.25~1.8s, such as the system is suitable for a speed range 0~200km/h，t＝1.8s，so：$0 < D < 100m$

Limited by the location principle, 0m that the minimum detection distance is impossible to achieve, as required, even after the vehicle stopped in front of obstacles still remain between 2~5m distance, so take the minimum detection distance of 2m can meet the requirements.

If vehicle is in a motion dynamic environment, the detection distance range requirements can be expressed with the following:

$$t \times v_{\min} < D < t \times v_{\max} \tag{3}$$

In order to ensure timely and accurate manner since the car was found on the threat to the security objectives, the level of detection angle range should be large enough, but the program is too large to bring the system to achieve the practical difficulties in terms of the level of detection range of the general requirements in the 10m detecting distance At least there should be covered by the width of the detection range from the car. General car car width is not greater than 2m,so:

$$\theta = arctg\left(\frac{2}{2 \times 10}\right) \approx 6^{\circ} \tag{4}$$

From the angle detection range , the level of style is 12°. To ensure that the vehicle can be found under the rough conditions, such as in front of goal, radar beam in the vertical direction there should be some coverage angle, taken as 3°.

For the distance measurement error and angle measurement error, requiring the smaller the better. As the error decreases, the corresponding increase in system cost, detecting the signal-processing complexity increase, generally require distance measurement error $\pm 1m$, measurement angle of resolution 1°, angle measurement error $\pm 1^{\circ}$.

5 Conclusion

Development of anti-collision radar system must consider ability cost and technical achievability. Due to automotive anti-collision radar bad working conditions, false alarms may arise from a variety of factors: the near driveway of the vehicle lane between the guardrails, roadside trees and signs and so on which will cause interference to the radar system. It is important and difficulty that how to obtain low false alarm rate.

Vehicle safety is not just technical issues, but rather a engineering system consist of person, vehicles, roads, management, etc. Cars and drivers, cars and objects, collision of cars and people is the main form of traffic accidents. Therefore, intelligent anti-collision system is the forefront of automotive active safety issues, all countries and relevant corporate research focus on it. This article only describes one of the vehicle active safety technology that is automotive collision avoidance warning system, nip in the bud, car Security technology requires further study.

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