Research on Intelligent Anti-collision Device of Heavy Truck Based on Wireless Communication Technology

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Abstract. The increase in the number of vehicles, rapid development of road traffic, traffic accidents have become increasingly serious. However, these sensors have some limitations, such as single detection direction, detection blind area, and can not realize long-distance transmission. So they can not meet the current requirements. Based on this, the intelligent anti-collision device of heavy truck based on wireless communication technology is put forward. The intelligent anti-collision research of heavy truck is realized by designing the display interface of intelligent anti-collision device, constructing anti-collision early warning database and modulating and demodulating algorithm based on wireless communication technology. Tests show that the wireless communication module and the collision warning and display function of the intelligent anti-collision device can run successfully, and the overall performance of the device is reliable and stable.

Keywords: Wireless communication technology · Heavy-duty truck · Intelligent anti-collision device

1 Introduction

There are many ways to achieve wireless communication technology, the current mainstream communication technology to DSRC and LTE-V mainly. The most widely used V2X communication technology is the Dedicated Short Range Communication (DSRC) technology based on the IEEE 802.11p and the IEEE 1609 series standards. LTE-V is an extended technology based on the fourth generation mobile communication technology. The current version of LTE-V is 4.5G technology [1].

At present, the domestic and foreign main such as Benz, Honda, Volvo and other automotive enterprises equipped with vehicles common collision warning system, as an assistant driver. The Mercedes-Benz Pre-Safe Brake system for vehicles uses millimeter radar to detect the vehicle ahead, is equipped with a microwave detector, and is equipped with a brake assist system that warns 2.6 s before a collision is identified, gives a second warning 1.6 s before a collision, performs braking control on the vehicle if the driver has not yet taken a substantive collision avoidance operation, and outputs a maximum

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braking deceleration 0.6 s before a collision [2–4]. Toyota's Pre-Collision Active Collision Avoidance system combines millimeter-wave radar, cameras and infrared sensors to improve ambient detection accuracy, and infrared sensors enable vehicles to detect dangerous targets at night [5]. When it is determined that a collision is imminent, the system automatically tightens the seatbelt and performs auxiliary braking when the driver depresses on the brake pedal, so that the vehicle can achieve maximum braking force and minimize the impact force and damage [6–9].

The core of collision prevention and early warning system is early warning strategy [10]. Many universities and scholars at home and abroad have conducted in-depth research on collision prevention and early warning strategy. There are two kinds of anti-collision algorithms: the safe time algorithm and the safe distance algorithm. Select the vehicles that may collide in a certain range of time, predict the trajectory, calculate the collision time TTC, when the TTC in the set range, judge the potential collision risk. This paper designs an intelligent anti-collision device for heavy-duty trucks based on wireless communication technology. Through wireless communication technology, the transmission performance of information such as position, speed, distance and braking distance of heavy-duty trucks is improved. Collision warning model with braking distance as parameter. Design a risk assessment model based on braking distance, collision time and lane change safety distance, and calculate risk level and intervention time in real time.

2 Research on Intelligent Collision Avoidance Device for Heavy Trucks Based on Wireless Communication Technology

2.1 Design of Display Interface for Intelligent Anti-collision Device

Good user interface is very important to improve the usability of anti-collision device. The control of the login interface includes "user name", "password", "login" and so on.

Table 1. Interface structure of intelligent anti-collision device

Button	Features
Domain name	Enter the anti-collision warning IP address
Username	Enter the anti-collision device administrator account
Password	Enter the administrator password
Log in	Click the "Login" button to log in to the alert server with the administrator information entered

As shown in Table 1, it is the interface structure of the smart collision avoidance device. The main interface displays map information by default, and displays the location of the train after the map is matched on the map. The location of the train is updated every time the location data is updated. Ensure that the location update information of

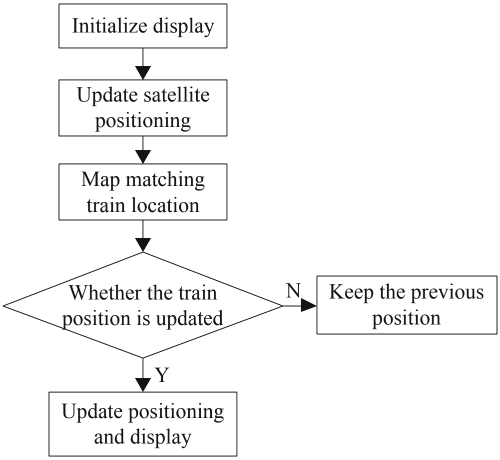

Fig. 1. Heavy truck location information update process

heavy trucks is displayed in the anti-collision device interface. The specific location update process is shown in Fig. 1.

As shown in Fig. 1, in the intelligent collision avoidance device interface of heavy trucks, the location information of the truck is updated in real time. First, the location of the truck is initialized to display the location of the truck. Based on the satellite positioning space position, combined with the map function in the interface, it is matched to the geographic information of the truck., The final update positioning is successful and displayed in the interface. The setting interface contains a record query menu, which can query the communication records in the heavy truck operating database, and record the record items contained in the query menu, as shown in Table 2.

Table 2. Record query menu item settings

Record item	Features
Early warning record	Can query historical warning records recorded in the database
Call log	Can query the historical call records recorded in the database
Recording	Can query the recording records of calls in the database

As shown in Table 2, the interface designed for this article records query menu item settings and features.

The Alert Settings Window sets up the alert parameters, which are opened by the button in the menu bar, and the Alert Time Edit Box on the left, which sets up the specified alert interval. You can also quickly select a preset warning interval by using a drop-down menu. The list of alert targets shows the ID list of the terminals that currently join the alert function. The terminals in the list can receive alert information in the alert area. You can edit the list of alert targets by removing and adding buttons.

The voice call in the display interface is very important to avoid the collision of heavy trucks. Voice call means that the early warning system can talk with the terminal directly. In the number box, enter the terminal number you want to call. Voice call calls have two properties: an emergency call and a broadcast call. To make an emergency call, check the box in front of Emergency Call. To make a broadcast call, check the box in front of Broadcast Call. When the number is entered, click the "PTT" button or press the space bar on the keyboard to initiate a voice call. The voice call has been successfully paged out and the call window will pop up [11]. Can view all the terminal information registered in the alarm intercom scheduling desk, can enter the number to query, in the list of selected terminal number in the main interface display terminal information and location. In addition to receiving the terminal to confirm the early warning message, but also to distinguish the general message warning icon for display. When the terminal receives the alarm information, it prompts with the alarm interface and exits the prompt after selecting the safety button. In the offline state, the terminal display interface status bar to exclamation icon reminder, while offline using the alarm window to remind, and every 10 s to remind the tone reminder, until the terminal online again.

2.2 Building an Early Warning Database for Anti-collision Devices

First, design an early warning database. Since the smart collision avoidance device uses handheld terminals, it is necessary to establish a terminal information table to record all the registered terminal information, which contains the terminal equipment number and the information of its users. Because heavy truck information is needed in the early warning, it is also necessary to establish a heavy truck number information table. The generated early warnings need to be recorded, so an early warning record form needs to be established, as shown in Table 3.

Table 3. Early warning information record table

Field name	Type	Constraint	Illustrate
ID	NUMBER	Not null	
Time of warning	VARCHAR2(14)	Not null	Complies with the valid date and time format, year, month, day, hour, minute, and second
Warning type	VARCHAR2(2)	Not null	Divided into: SMS alert, voice call
Warning station	VARCHAR2(6)	Not null	
Warning end time	VARCHAR2(14)	Not null	
Target confirmation	VARCHAR2(2)	Not null	Divided into: confirmed, unconfirmed
Heavy truck number information	NUMBER	Not null	

As shown in Table 3, an early warning configuration information table is established to record the early warning parameters, including the early warning time, the early warning type, and the early warning end time. Since the intelligent anti-collision device also uses the location data of the construction site, it is also necessary to establish a construction area data table. In addition, there are recording information tables for recording early warning calls, attendant registration tables for recording station attendant login information, and reporting information tables for recording early warning reports. In order to be able to use the map matching method to correct the positioning, it is also necessary to establish a digital map database, which contains the segment point calibration table used to correct the coordinates of the segment point, and the curve information table used to identify the segment curve (including all the divided curves Km coordinates and radius of curvature of the start and end points) [12].

This paper designs the E-R relationship of the database, as shown in Fig. 4 and Fig. 5. Due to the large number of data tables, this article only describes the design of representative data tables.

Table 4. On-duty officer login information table

Field Name	Type	Constraint	Illustrate
ID	NUMBER	Not null	
Username	VARCHAR2(10)	Not null	Login user name, 2–10 characters
User type	VARCHAR2(2)	Not null	Divided into: system administrator, attendant on duty, assistant attendant on duty
Station name	VARCHAR2(12)	Not null	
IDStation ID	VARCHAR2(6)	Not null	
User rights	VARCHAR2(20)	Not null	Divided into: administrators, attendants on duty
Password	VARCHAR2(10)	Not null	6–20 characters, composed of letters and numbers

Table 4 is mainly responsible for recording the information of the attendants who log in to the early warning walkie-talkie dispatching station.

Table 5. Configuration table of anti-collision warning rules

Field name	Type	Constraint	Illustrate
ID	NUMBER	Not null	
Warning time	VARCHAR2(4)	Not null	00 (min) 00 (s)–59 (min) 59 (s)
Collision avoidance distance	NUMBER	Not null	Unit: 100 m
Longitude and latitude of anti-collision starting point	VARCHAR2(8)	Not null	Complies with the latitude and longitude format, such as east longitude $23°27'30''$ means east longitude 232730
Longitude and latitude of collision avoidance terminal	VARCHAR2(4)	Not null	
Urgent escalation	VARCHAR2(8)	Not null	Divided into: report all, report failure early warning, never report
Collision avoidance warning target confirmation	VARCHAR2(2)	Not null	Divided into: mandatory, optional

As shown in Table 5, it is primarily responsible for recording early warning configuration information. Through the above pre-warning information record table, the log-in information table of duty personnel and the pre-warning rule configuration table, the pre-warning database of anti-collision device is constructed.

2.3 Modulation and Demodulation Algorithm Based on Wireless Communication Technology

The core algorithms of this paper include modulation and demodulation algorithm used in DMR wireless communication technology and map matching algorithm used in location correction [13]. Modulation is to use the baseband signal to control the change of one or several parameters of the carrier signal, and load the information on it to form a modulated signal for transmission, while demodulation is the inverse process of modulation. The change will restore the original baseband signal. The modulation and demodulation algorithm mainly accomplishes the modulation and demodulation of 4FSK signal, and its performance has great influence on communication distance and speech quality. In order to improve the precision of map matching, the paper uses the method of tangent line to improve the precision of map matching on curve orbit. The model of digital wireless communication includes source codec, channel codec, modulation and demodulation, etc. The intelligent model structure of wireless communication technology is shown in Fig. 2.

As shown in Fig. 2, source coding, also known as band compression coding, can reduce the rate of code elements and the number of code sources without distortion recovery. The source decoding transforms the information in the opposite way to the source encoding process. Channel coding is to counter the noise and attenuation in the

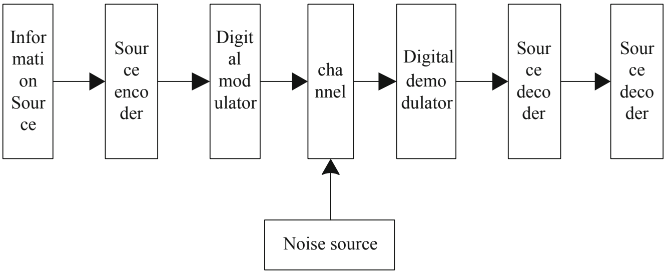

Fig. 2. Intelligent model structure of wireless communication technology

channel by adding redundancy codes to the transmitted information codes in a certain way to form new code words, and the receiver then detects or corrects errors in a corresponding way so as to achieve the purpose of improving the anti-interference and error correction capabilities [14]. Channel decoding is the process of restoring the code elements after channel coding. In order to improve the transmission efficiency of the signal, the spectrum of the digital baseband signal is moved to the high frequency, so that it can improve the utilization of spectrum resources.

DMR standard chooses 4FSK as its modulation and demodulation mode. 4FSK is a constant envelope modulation technology, whose characteristic is that the peak value of pulse envelope is constant in a certain time, and this modulation technology has high spectrum utilization. The process of 4FSK modulation is that the signal is filtered by shaping filter after level transformation, then the filtered signal is processed, and finally filtered by first-order RC filter. According to Nyquist criterion, it is possible to eliminate ISI only when the symbol rate is less than 2 times the channel bandwidth. Consider natural filters, the frequency offset expression for rectangular filters is:

$$h(t) = \begin{cases} 1 \leq t \leq \dfrac{T_s}{2} \\ 0 \geq t \geq \dfrac{T_s}{2} \end{cases} \tag{1}$$

Among them, $h(t)$ represents the frequency deviation of the rectangular filter; T_s is the constant of the filter index. The bandwidth of this rectangular pulse is infinite, the out-of-band power decays very slowly, and out-of-band leakage occurs. In practical applications, it is generally not used as a shaping filter. In order to solve the problem of out-of-band leakage, consider a rectangular function in the frequency domain to completely limit the power within the band. The calculation formula for the impulse response is:

$$h(m) = \frac{\sin(\pi t/T_s)}{\pi t/T_s} \tag{2}$$

This article uses a root raised cosine filter, this filter realizes the rapid attenuation of the time domain signal at the cost of widening the frequency band, and at the same time, in order to reduce the loss of the band widening, a roll-off is added on the basis of the raised cosine filter. Coefficient α, the value interval is [0, 1]. The smaller α is, the closer to the rectangular filter, and the larger the α is, the closer to the cosine filter. By adjusting the roll-off coefficient, the occupied bandwidth and attenuation speed can be adjusted.

To realize this filter, we must first generate a set of filter coefficients corresponding to the order of the filter. This article uses Matlab functions to generate filter coefficients. The function expression is as follows:

$$functionB = r\cos fir(r, N-T, rate+1, T) \tag{3}$$

Among them, parameter r represents the roll-off coefficient, $N-T$ represents scalar or vector; together with *rate*, determines the length of the filter output, *rate* represents the sampling rate; T represents the sampling period of the input signal, in seconds, used to generate ordinary raised cosine filters Coefficient, when $N-T$ is a scalar, B returns a one-dimensional array of length $rate+1$, which is the coefficient of the required root raised cosine filter. In order to facilitate the calculation in the DSP, the set of coefficients need to be further fixed-point to 16-bit integer processing, that is, each number is multiplied by 2^{15}, so that the accuracy of the coefficient can be maximized when the coefficient is used, and the transformed coefficient is put into the array. After calculating the coefficients of the filter, the operational relationship between the input and output of the filter can be established. The output of the FIR filter is obtained by the convolution operation between the input data and the tap coefficient of the filter. The formula is as follows:

$$y(n) = \sum_{k=0}^{n} x(k) \cdot h(n-k) \tag{4}$$

Among them, k is the FIR filter coefficient; $y(n)$ represents the input of the filter at time n; $x(n)$ represents the output of the filter at time n. This kind of convolution operation is to add or subtract the input data (according to the positive or negative of the input data) to the product of the previous filtering operation result and the corresponding filter coefficient, and output the operation result as the input of the subsequent stage. According to the DMR wireless communication protocol, a frame of data contains 288 bits. After serial-parallel conversion, 144 symbols are obtained, which is a four-level signal. Then the four-level signal is interpolated by 8 times to obtain the input data of the root raised cosine filter.. Next, the characteristics of the root raised cosine filter are tested by adding Gaussian white noise to the input signal. The entire inspection process is completed by matlab simulation. First, grab a set of input data with a length of 1152, the data type is a 16-bit unsigned integer, the value range is 0 to 4096, as the original input signal.

3 Experiment and Analysis

3.1 Experimental Preparation

In order to verify the effectiveness and performance of the intelligent anti-collision device for heavy truck based on wireless communication technology, and to avoid the danger and high cost of real vehicle test, this paper chooses Prescan and MATLAB/Simulink joint test. The use of feature-oriented parametric modeling, including the setting of vehicle dynamic parameters, can reduce the experimental cost and shorten the development cycle. It can be used for simulation verification related to unmanned and active safety, such as automatic emergency braking system, orbit deviation early warning system, etc. Track has rich traffic scene elements, including a variety of straight lines, curved sections, all kinds of vehicles, pedestrians, obstacles, and so on, and can detect the surrounding environment of a variety of sensors. Input the measured data, can also be set parameters to get the required data, into the control module algorithm, output test results. In the user interface (GUI) operation, the establishment of the intersection confluence and follow the same road these two traffic scenarios for experimentation, the possibility of collision collision and side collision early warning performance comparison. The vehicle simulation model is established and the state parameters of the vehicle are set up. After setting up the speed and acceleration (spot) of the vehicle, setting up the speed, acceleration, trajectory and other parameters of the vehicle in the process of movement, it is necessary to add corresponding sensors to all vehicles within the communication scope. Version 8.4.0 of Pre Scan supports the DSRC communication protocol and the SAE J2735 protocol for V2X communication experiments. Drag the V2X wireless communication device onto the vehicle body on the GUI interface, configure the V2X plug-in parameters, preprocess the acquired data, establish the pretreatment module, and then build the corresponding MATLAB function module according to the ITTC model and the TTW model. The input of the model is the state and position of the vehicle, and the output is the warning information. The 3D visual interface is used to observe the road and the warning result.

3.2 Analysis of Results

Assuming that the vehicle starts from the initial position 0 at a speed of 60 km/h, and accelerates to 100 km/h after 5 s, the change of acceleration is constant, and the simulation records the motion state of the vehicle for 20 s. The algorithm in this paper is used to predict the total travel distance of the vehicle after 20 s of driving, and the error between the predicted position and speed and the actual position and speed of the vehicle is used as the performance standard. The result of the vehicle position prediction is shown in Fig. 3.

As shown in Fig. 3, the simulation value and predicted value curve of the horizontal position and the longitudinal position of the vehicle position prediction result are basically fitted, and the vehicle position prediction error is expressed by calculating the difference between the predicted position of the vehicle and the actual position of the vehicle. This test case, The prediction error of the horizontal position is -0.015 ± 0.252 m, and the prediction error of the longitudinal position is 0.089 ± 0.207 m. The result of vehicle speed prediction is shown in Fig. 4.

As shown in Fig. 4, the prediction error of vehicle speed is calculated by predicting vehicle speed and actual vehicle speed. The results show that the prediction error of lateral speed is -0.028 ± 0.279 m/s and that of longitudinal speed is -0.064 ± 0.231 m/s. The experimental results show that the prediction data of the intelligent anti-collision

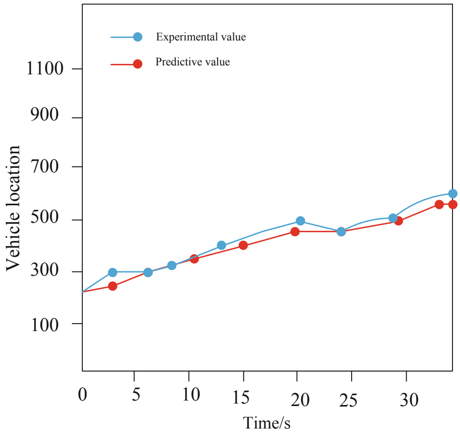

Fig. 3. The result of vehicle position prediction

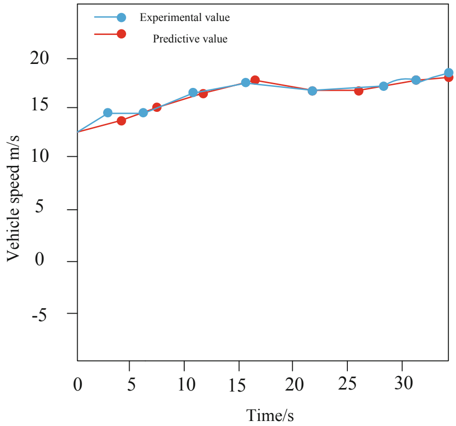

Fig. 4. The result of vehicle speed prediction

device based on wireless communication technology is less than the real data, and the prediction results can be used in anti-collision scheme.

The test of early warning and display module is to test whether the data received by the early warning system can be correctly pre-processed, whether the data input early warning algorithm can correctly judge the collision risk of vehicles, and can trigger the correct early warning information display according to different scenes. Because the communication function and information collection function of the system have been tested, considering the actual test environment and feasibility, the simulation value is used to test the vehicle state information.

In the user terminal interface, the relative positions of the front and rear vehicles can be visually displayed according to the vehicle information in the radar chart, and the corresponding information of the vehicle can be displayed correctly. It can judge that the type of collision between the front and rear vehicles is a rear collision, and display the warning information in the warning information status bar. Early warning success rate test: By setting the heading angle and trajectory parameters of the vehicle, setting the rear-end collision and side collision scenarios of two vehicles, the terminal runs 100 times for each collision, and runs 200 times to verify the success rate of the early warning function. The success rate of the early warning function is shown in Table 6.

Table 6. Results of early warning success rate of anti-collision device

Collision type	Number of successful warnings	Success rate
Rear-end collision	100	100%
Side collision	100	100%

As shown in Table 6, the test results of the early-warning and display module show that the early-warning and display functions of the user terminal are realized normally, and the position, speed, relative distance and other information of the vehicles can be displayed correctly, and the relative position of the two vehicles can be displayed visually in the radar chart, and different warning information can be displayed according to different collision types. The success rate is 100%, which shows that the performance of the anti-collision pre-warning function is stable, and the pre-warning and display modules meet the requirements of intelligent anti-collision.

4 Conclusion

Based on the research of wireless communication technology and the analysis of existing anti-collision early warning algorithms, an intelligent anti-collision device for heavy trucks is designed and implemented. Based on the analysis of vehicle movement in both transverse and longitudinal directions, the impact of vehicle velocity and acceleration parameters on collision risk assessment is considered. The test results show that the wireless communication module and the function of collision warning and displaying can be operated successfully, and the overall performance of the device is reliable and stable.

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