Automobile Braking Performance Detection System Based on Binocular Stereo Vision

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Abstract. Braking performance is one of the important items of vehicle safety performance testing, and good braking performance is an important guarantee for vehicle safety driving. This paper mainly studies the vehicle braking performance detection system based on binocular stereo vision. The visual inspection system runs in Windows XP operating system. The stereo vision system software for automobile braking performance inspection is developed by using MATLAB and Visual C++. At the same time, SQL Server 2005 database is used. When the vehicle speed reaches the set speed, manually disconnect the clutch on the bench, and give the driver the command to press down the brake pedal to make the four wheels rotate freely. At the same time, the acquisition system starts to collect braking data, observe the curve change trend in the main interface of the acquisition system, and debug repeatedly until it is consistent with the actual situation of automobile braking. In this paper, the binocular stereo vision ranging system has high accuracy in short distance ranging. The ranging error is less than 1% in 10 meters and less than 5% in 15 meters. The results show that the system designed in this paper has the advantages of low development cost, short cycle, easy function expansion, easy to carry and so on.

Key words: Braking Performance, Stereo Vision, Camera Calibration, Braking Trajectory

1. Introduction

At present, China's automobile industry is facing both crisis and opportunity. On the one hand, the shrinkage of the automobile incremental market and the immaturity of the replacement market cause the main engine manufacturers, dealers and parts manufacturers to face greater pressure for survival. On the other hand, with the continuous development of automobile electronics, communication, big data and other fields, China's automobile industry is facing more and more challenges, and China's automobile industry also has such industrial growth points as "new four modernizations".
The traditional test methods can not meet and adapt to the current fierce market competition. Only by quickly mastering the new fatigue strength and wear durability test technology, can manufacturers enhance their strength, firmly occupy the domestic market and even enter the international market [1-2]. Therefore, the demand for efficient real-time pedestrian detection technology using computer, sensor and other software and hardware technology is becoming increasingly urgent [3]. It is necessary to be able to monitor the pedestrians in front of the vehicle in real time, analyze and track the movement behavior before the traffic accident, and also be able to predict and warn the potential hazards in time [4-5]. This can not only protect pedestrians, but also reduce the occurrence of traffic accidents. At the same time, it can relieve traffic pressure and effectively protect the life and property safety of drivers and pedestrians [6]. In terms of fuel economy and production and transportation efficiency, good braking performance can bring significant economic benefits [7]. From the perspective of vehicle safety detection, vehicle braking performance detection is in a pivotal position. Through the technical means of vehicle detection, the safety performance of vehicles can be effectively improved, so as to reduce the vehicle accident rate, reduce vehicle accidents to a certain extent, and reduce personnel and economic losses as much as possible [8-9]. At the same time, through testing, the production level of automobile can be improved, the production cost can be reduced, and the consumption of raw materials and oil can be reduced [10].

Binocular stereo system is usually used to reconstruct the scene from different positions to obtain a pair of left and right images, and uses image processing technology to process the left and right images in real time to provide stereo matching technology. Using image processing technology to process parallax map, combining projection geometry and triangulation, the depth information is calculated synthetically, and the three-dimensional information is reconstructed.

2. Automobile Braking Performance Detection System

2.1. Binocular Stereo Vision

Binocular stereo vision as a passive sensor itself does not emit any signal, but only passively receive environmental information. Therefore, compared with the radar sensor, the structure of the vision sensor is simpler, the energy consumption is lower, and the concealment is better. At the same time, because the autonomous resource exploration vehicle works in the field environment, the driving situation is complex and changeable. No matter what kind of scene, the matching algorithm should have good matching accuracy, which requires the algorithm to be able to adapt to different scenes and have good robustness.

For images that can be directly compared, the general evaluation indexes are mean square error (MSE) and peak signal-to-noise ratio (PSNR). Resolution is an evaluation method used to evaluate the image quality without reference.

Let \( f(x, y) \) be the image after noise interference, the considered pixel tone value is \( g(i, j) \), and centered on this, the output after neighborhood averaging is as follows.

\[
g(i, j) = \begin{cases} 
\frac{1}{M} \sum_{(x, y) \in S} f(x, y) & \text{if } f(i, j) - \frac{1}{M} \sum_{(x, y) \in S} f(x, y) \geq T \\
\text{else} & 
\end{cases}
\]  \hspace{1cm} (1)

\( T \) is an adjustable parameter, and \( M \) is the size of the averaging window.
The formula of the GMG algorithm is expressed as follows.

\[
GMG = \sum_{i=1}^{M-1} \sum_{j=1}^{N-1} \sqrt{\frac{[g(i+1,j)-g(i,j)]^2 + [g(i,j+1)-g(i,j)]^2}{(M-1)(N-1)}}
\]  

(2)

The LS algorithm formula is expressed as follows.

\[
LS = \sum_{i=2}^{M-1} \sum_{j=2}^{N-1} \frac{|8g(i,j)-g(i,j)-g(i-1,j)-g(i,j-1)-g(i,j+1)-g(i+1,j+1)|}{(M-2)(N-2)}
\]  

(3)

In the formula, \( g(i,j) \) is the gray value in (i, j) of the image.

2.2. Automobile Braking Performance Detection System

To meet the specific needs of braking performance test, the test system provides a foundation for the realization of the hardware part of the test functions, the software part is defined instrument functions, the hardware system using effective organization, implementation of test data acquisition, processing, analysis and processing, and according to the role of insurance operation procedures to complete the cloth to reduce test project. By detecting the three forces of each wheel, namely the longitudinal force, the transverse force and the vertical load of the tire, the direct parameters such as the braking distance and the transverse displacement of the whole vehicle are obtained after calculation. These parameters can truly and objectively reflect the braking performance of the whole vehicle. It is a new automobile braking performance detection method with the same detection parameters as road test detection method.

3. Simulation Experiment of Automobile Braking Performance Detection System

3.1. Experimental Environment

The running environment of this visual inspection system is Windows XP operating system, using MATLAB and Visual C++ to develop stereo vision system software for automobile braking performance inspection, and using SQL SERVER2005 database. The program of this system runs in the industrial computer of the brake performance detection station, and its input data is input into the industrial computer through the A/D card. After the program is processed, it is displayed on the terminal display of the station, and the processed data passes through the network cable is transmitted to the SQL Server database of the remote server.

3.2. Detection Process

When the vehicle speed reaches the set speed, manually disconnect the clutch on the platform and give the driver instructions to depress the brake pedal to make the four wheels in a free rotation state. At the same time, the acquisition system starts to collect braking data, observes the trend of the curve displayed in the main interface of the acquisition system, and repeatedly debugs until it is consistent with the actual braking situation of the car.
4. Discussion

4.1. System Test Results

The wheel speed is shown in Figure 1. It can be seen from the figure that the initial braking speed of the vehicle is about 58km / h, which is smaller than the set initial speed of 60km / h. The slowing down trend of the curve contour of the vehicle braking speed obtained from the experiment is relatively stable, and many of the curves appear zigzag shape, and a few of them have large fluctuation amplitude, and the collected wheel speed data has large amplitude. These are caused by the disturbance of the test-bed vibration, the accuracy of the acquisition instrument and the error of the program itself. But from the general trend of velocity change, the test results are basically consistent with the actual situation. After braking, measure the deviation distance of the vehicle relative to the driving channel with a meter ruler, that is, the lateral path deviation of the vehicle is 0.41m. About 0.7 seconds, the brake starts to take effect, about 1.5 seconds, the braking force reaches a stable value, this period is about 0.7-0.9 seconds, is the process of braking force growth. Since then, the braking force is basically stable around 1950n, which is the braking time, and the deceleration process of the wheel is mainly in this period of time. When the vehicle speed reduces to about 0, the braking force starts to release, which takes about 0.4 seconds.

![Figure 1. Wheel speed](image)

The statistical results of different distances are shown in Figure 2. When using the feature matching method based on the center point of pedestrian detection frame as the feature point, the calculated distance is smaller than the actual distance when the distance between pedestrian and vehicle is less than three meters, so the absolute error and relative error are both negative, and the relative error is less than 0.1%. When the distance between pedestrian and vehicle is between three meters and five meters, the maximum error is 0.121 meters, and the maximum relative error is 2.670%. When the distance between people and vehicles is more than 10 meters, the absolute error is 0.516 meters, and the relative error is 5.142%. However, due to the interference of the foreground information of the target in the image, there may be small objects in front of the target in the target image area, which makes the binocular stereo vision system misjudge its smaller depth distance as the distance of the recognized target. Therefore, the pixel coordinates of the center point of the target area are calculated according to the corner coordinates of the rectangular frame of the target. The depth distance of the
target center is calculated by the matching parallax of the center point, which is also used as the auxiliary reference of the target distance.

![Image](image-url)

**Figure 2.** Measurement statistics for different distances

### 4.2. Comparison of Detection Accuracy

Static ranging results and errors are shown in Table 1. It can be seen that due to the influence of the focal length and baseline distance of the selected binocular camera, the accuracy of the binocular stereo vision ranging system in this paper is higher in the short distance ranging, and the ranging error is less than 1% in 10 meters and less than 5% in 15 meters. However, when the target distance is more than 10 meters, the error of binocular ranging begins to rise with the increase of distance, which is mainly caused by the cumulative superposition of system error and human error. After PID control, the number of pulses is stable around 17500, and the expected control purpose is achieved. PID control method to achieve the expected speed faster, after 10 seconds of program running, it reached the expected value, but the overshoot appeared, about 25 seconds to alleviate the overshoot, the steady-state performance is poor, and the interference is more serious. Limited by the adhesion factor of the brake test bench and the condition of no-load vehicle, the actual braking capacity of all wheels can not be detected on the roller brake test bench or the flat brake test bench when the vehicle with full load braking performance is qualified. The test results show that the no-load heavy vehicle bench test can only detect about 50% of the actual braking force of the wheel.

| Serial number | Actual distance/mm | Measuring point coordinates | Binocular distance measurement/mm | Average distance/mm | Ranging error |
|---------------|--------------------|------------------------------|----------------------------------|--------------------|---------------|
| 1             | 1000               | (568,318)                    | 1002.08                          | 995.18             | -0.48%        |
|               |                    | (853,308)                    | 993.12                           |                    |               |
|               |                    | (802,562)                    | 990.34                           |                    |               |
5. Conclusion

This paper analyzes and designs the real-time control technology of the slip rate between the wheel and the roller, which realizes the accurate control of the stop time of the drive motor, and accurately controls the slip between the wheel and the roller.

According to the longitudinal displacement and lateral displacement of the vehicle, the braking trajectory of the vehicle can be obtained, so as to judge the braking performance of the vehicle. This method can reflect the braking performance more accurately and objectively than the previous method which only takes the braking force as the evaluation parameter, especially for the detection of vehicle braking stability.

Aiming at the complex functions of the system, the software of the system is designed by using LabVIEW, which makes full use of the modular design method and effectively subdivides the complex functions into small modules that are easy to realize and understand.

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