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Research on road identification method in Anti-lock Braking System

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Abstract

Road identification is an important premise to the anti-lock function. The ABS control algorithm is put forward on the basis of the analysis of the ABS control process. Combining with the first pressurization time, the dropped wheel speed and the slope of the dropped speed at the end of decompression, a road identification method is put forward. The vehicle road test verification is conducted. The result indicates that the method can achieve real-time identification to various road conditions.

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Keywords: ABS; road identification; road test;

1. Introduction

Accurate and timely road identification serves as an essential prerequisite for ABS. Therefore, according to Chen Jun etc[1,2], road identification can be achieved by neural network technology. Yu Zhuoping etc[3] identify the road based on Kalman filter methods. Hahn etc[4] used GPS to identify the friction factor of tires and ground; Zheng Taixiong[5]compared the practical calculation of tire-road friction coefficient with theoretical tire-road friction coefficient as the theoretical basis to identify road. This paper proposed a method to identify road using the first pressurization time, the dropped wheel speed and the slope of the dropped speed at the end of decompression.

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2. ABS control method

In our proposed improved logic threshold control method, the single wheel control process includes the first control① and the conventional control cycle②, shown in Fig.1. First control is a control process that the wheel speed starts to descend at the early braking period until the speed starts to rebound. It includes two state of first pressurization "a" and decompression "b". Conventional control cycle is a control process that the wheel speed starts to rebound until the speed descends to nadir again. It includes three state of pressure maintaining "c", ladder pressurization "d" and decompression "e". First control appears only once in the entire control process, conventional control appears circularly. v_A is wheel speed at point A, v_C is the wheel speed at point C, t_1 is the first pressurization time, t_2 is the decompression time in the first control. Thus two variables is concluded in the first control, the dropped wheel speed v_s (1) and the slope of the dropped speed a_s (2).

$$v_s = v_A - v_C \quad (1)$$

$$a_s = (v_A - v_C)/t_2 \quad (2)$$

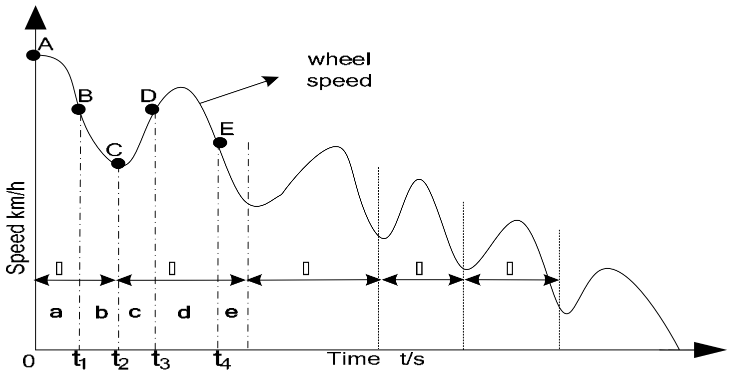

Fig.1. control process of single wheel

3. Road identification method

In order to simplify the research system, 1/4 vehicle model is adapted, as shown in Fig.2

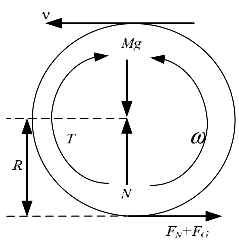

Fig.2. single wheel vehicle model

Vehicle motion equation, wheel motion equation and longitudinal friction equation are given as:

$$Mv' = -F_N - F_G \tag{3}$$

$$J\omega' = R(F_N + F_G) - T \tag{4}$$

$$F_N = \mu N \tag{5}$$

Where, M is the mass of the vehicle; ω is wheel angular velocity; v is wheel speed; F_N is the friction between wheel and ground; F_G is wheel rolling resistance; T is braking torque; R is vehicle radius; J is wheel rotation inertia; μ is road adhesive coefficient; N is the vertical counterforce between ground and wheel.

3.1. The influence of the first pressurization time to the road identification.

In order to make full use of the adhesive coefficient at the first control cycle, the reference sliding rate and the wheel angle acceleration threshold under the first decompression state are the same, therefore $v_H > v_L$, because $\mu_H > \mu_L$, From (5), $F_{NH} > F_{NL}$, there is $T_H > T_L$. So we can identify road conditions by the first pressurization time. (H means high adhesive coefficient, L means low adhesive coefficient)

3.2. Analysis of the dropped wheel speed and the slope of the dropped speed at the end of first control

There will be maximum wheel speed difference between v_A and v_C when the first decompression exits. Because the road adhesive coefficient is different, the dropped wheel speed and the slope of the dropped speed should have obvious difference. In order to distinguish them, takes road tests respectively on the high and low adhesive coefficient road, folio road. 80 groups of data are chosen to analyse. We concluded that the dropped wheel speed $v_{sL} > 8km/h$ and $v_{sH} < 4km/h$ on two different adhesive coefficient road respectively, the slope of the dropped speed on two different adhesive coefficient road is $a_{sL} > 16m/s^2$ and $a_{sH} < 6m/s^2$ respectively, and $a_{sL} > a_{sH}$, and the two front wheels' speed difference v_d is relatively obvious, $v_d > 5km/h$. They can be used for identification.

4. The design of road identification scheme

The process of road identification is as follows, Fig.3 is a process description of the road identification when the vehicle is conducting ABS braking:

The specific process of the first road identification is:

(1) Firstly compare the first pressurization time of the two front wheels, if there is more than a, vehicles can be judged on the high adhesive coefficient road, otherwise, go to step (2).

(2) When a front wheel's decompression ends, judge the speed difference between this wheel and the other front wheel, if it is more then b1, we think it is on the folio road, if the left-front wheel speed is higher than right-front wheel, it is on the folio road with high adhesive coefficient on the left and low adhesive coefficient on the right, conversely on folio road with low adhesive coefficient on the left and high adhesive coefficient on the right.

(3) After the above two steps, if the road is still not identified and the decompression of the two front wheels is already over, we judge whether the two dropped front wheels speed is higher than b2 respectively, if so it is on the low adhesive coefficient road, conversely on the high adhesive coefficient road.

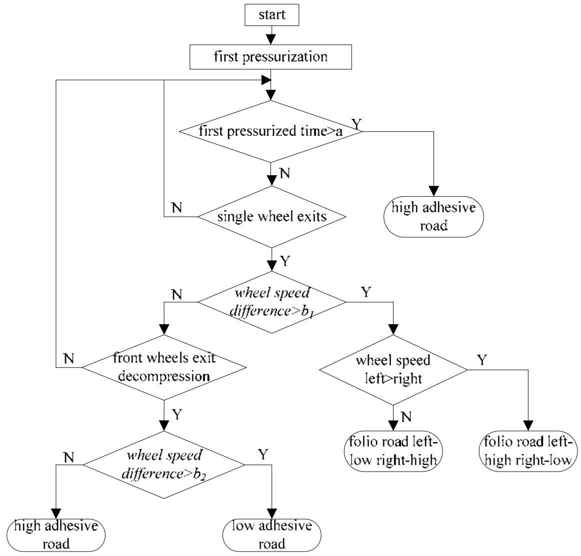

Fig.3. flow chart of road identification

5. Road test verification

To verify our method, road tests are done in Xiangfan Dongfeng proving ground. The results are shown in fig.4 and fig.5.

It can be seen from the Fig.4. (a), Time on the turning point is about 0.25s, the corresponding identification marks change from 0 to 16, so it is identified on the high adhesive coefficient road. As the Fig.4.(b), First decompression ends at 0.2s, and identification marks change from 2 to 0, the wheel speed drops from 40km/h into 30km/h, so it can be identified on the low adhesive coefficient road.

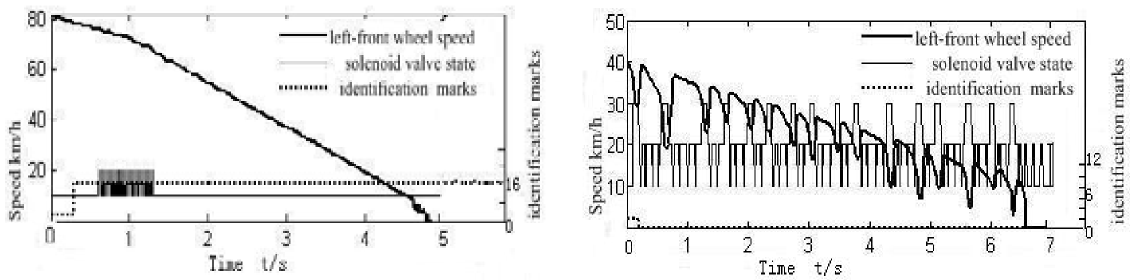

Fig.4. (a) testing graphics on the high adhesive road; (b) testing graphics on the low adhesive road

Concluded from Fig.5.(a), when the right-front wheel drops out of the decompression state, the identification marks change from 0 to 6, from Fig.5.(b), the left-front wheel speed is 48km/h, and the right is 34km/h, larger wheel speed difference between two front wheels is appeared. So it can be identified on the folio road with high adhesive coefficient on the left and low adhesive coefficient on the right.

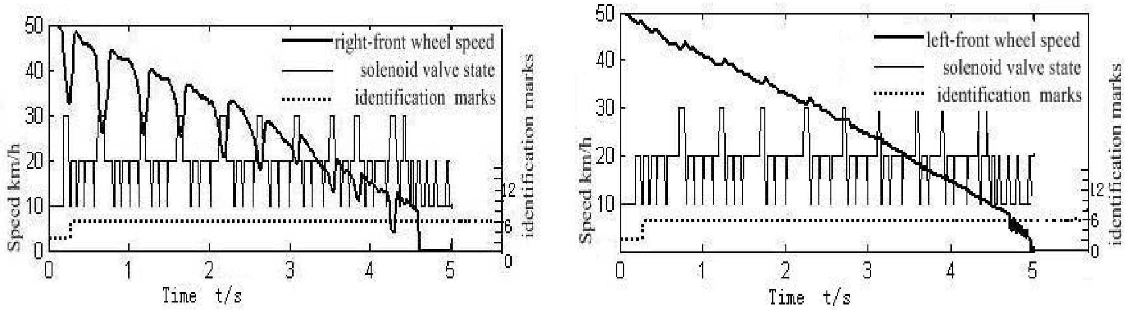

Fig.5. (a) testing graphics of right-front wheels on the folio road; (5) testing graphics of left-front wheels on the folio road

6. Conclusion

A road identification method combining with the first pressurization time, the dropped wheel speed and the slope of the dropped speed at the end of decompression is designed on this paper, and the method is used in self-developed ABS controller by our laboratory which can realize real-time identification to various road conditions. It can make vehicles get good braking effect and identification result, at the same time, the method can make the system run stably. It is proved that road identification plays an important role presently in the braking process, and this method is effective at present. Further research work for the automobile ABS system can be carried out basing on the method.

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