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Study on Vehicle Operating Safe State Monitoring Parameter and Measurement Model

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Abstract

Aiming to the present problems of vehicle operating safe state monitoring technology, study on vehicle operating safe state monitoring parameter and measurement model is proposed. Vehicle operating safe state monitoring parameters including monitoring vehicle's motion attitude parameter(MAP), dynamic load parameter(DLP) and braking performance parameter(BPP) of three key parameters are put forward, which is more comprehensive and scientific than ever. By establishing measurement model using WEIS to realize vehicle operating safe state parameter monitoring. Analyzed the connection among MAP, DLP and BPP information in reducing the unnecessary, repetitive physical sensing the amount of cases, some parameters that other traditional systems cannot measure can be obtained. The model forms a relative integrative and independent vehicle safety early warning monitoring platform, and has a great promotional value if information terminals access to Internet of Things.

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Keywords: Vehicle; Safe state monitoring; Motion attitude; Dynamic load; Braking performanc

1. Introduction

Vehicles Operating Safety States Monitoring (VOSM), as the primary means of ensuring safe driving of vehicles in the future, is also the inevitable trend for technology development of vehicles operating safety detection [1]. In Ref.2, the author already indicated that current vehicles safety monitoring parameters cannot meet the requirements of comprehensive and initiative monitoring, nor fully reflecting the actual safety state of vehicle operating; the monitoring parameters come from different sensor systems,

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being independent mutually, render the sensor information not be utilized integrally and efficiently and the vehicle performance not be integrally valuated and predicted; the data port and its platform for governmental administration section is also in lacking. It is a meaningful work to research the monitoring parameters and measuring model that can reflect the vehicles operating safety state totally and truly.

This paper indicates that Vehicles Operating Safety States Monitoring (VOSSM) system should include three key parameters: movement attitude parameter (MAP), dynamic load parameter (DLP) and braking performance parameter (BPP). The physical meaning of these parameters is discussed. By analyzing the relevance between these monitoring parameters, a model to monitor the vehicles operating safety state totally and truly basing on the Wheel Embedded Intelligent Sensors (WEIS) is promoted.

2. State monitoring parameters and its physical meaning

VOSM includes three key parameters: MAP, DLP and BPP.

Vehicles MAP consists of body MAP and wheel MAP. Body MAP is monitored to evaluate the danger of overall vehicle side-dump. It consists of body attitude angle (side-inclination angle Φ_B, longitudinal attitude θ_B, sway angle ψ_B), velocity (forward direction ν_{Bx}, side direction ν_{By}, vertical direction ν_{Bz}) and acceleration (forward a_{Bx}, side a_{By}, vertical a_{Bz}). The monitoring of wheel MAP mainly aims at the evaluation of unbalanced danger, looseness and flying-off of the vehicle wheel. The wheel MAP is consisted of the wheel i(i=1~4) attitude angle (extraversion γ_i, side α_i, sway β_i), velocity (tangential ν_{Wti}, side ν_{Wsi}, radial ν_{Wci}), acceleration (tangential a_{Wti}, side a_{Wsi}, radial a_{Wci}), and rotational parameter(angular velocity ω_i, angular acceleration ε_i). The wheel attitude angle directly reflects the states such as the tire load position, abrasion, tossing-off, side-movement and direction deviation; the wheel velocity and acceleration reflect the unbalancedness, looseness and flying-off trend of the vehicle wheel; rotational attitude indirectly reflect the degree and the trend of wheel slip.

Through measurement of Vehicles DLP, it can evaluate that whether the tire load is surpassed, or the barometric pressure and temperature is safe and how is the loading condition of the total vehicle, so as to prevent the vehicle from traffic accident due to over loading. Vehicle DLP is consisted of dynamic load L_i, real-time pressure P_i, temperature T_i and overall vehicle loading ΣL_i of the wheel i(i =1~4).

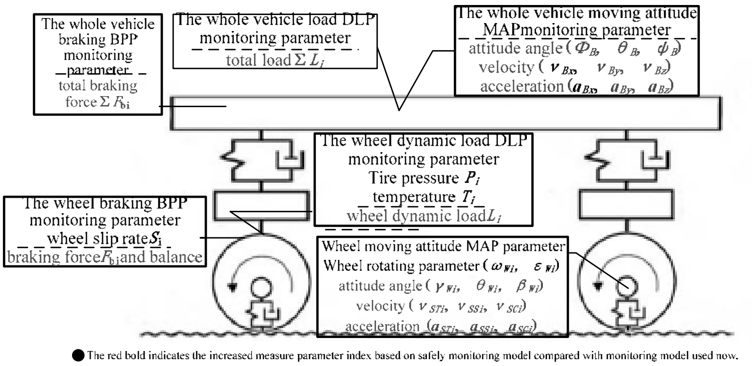

Fig.1 Vehicle operating safe state monitoring parameters

Vehicle BPP can be used to evaluate the braking performance of the wheel and the overall vehicle so as to prevent traffic accident due to braking false. Vehicle BPP is comprised of slip rate S_i, braking force F_{bi} and balance and overall vehicle braking force ΣF_{bi} of the wheel i(i =1~4). Among these parameters, the slip rate measures the best braking state of the vehicle anti-lock brake system; the braking force and balance parameters reflect the magnitude of the braking force of the wheel brake and the balance state of four-wheel braking force, respectively, which help the wheel to prevent some dangerous operating states such as off-tracking, side-slipping and losing turning-direction during the braking process; the overall vehicle braking force can be monitored to prevent traffic accident due to braking failure.

Fig. 1 plots the comparison between vehicle operating safe state monitoring parameter and monitoring model used now. The red bold indicates the increased measure parameter index based on safely monitoring model compared with monitoring model used now.

It can be concluded that: the mathematical modes of vehicle MAP body attitude angle (side-inclination angle Φ_B, longitudinal attitude θ_B, sway angle ψ_B)、velocity (side direction ν_{By}、vertical direction ν_{Bz})、acceleration (side direction a_{By}、vertical direction a_{Bz}) ,wheel attitude angle (extraversion γ_i, side α_i, sway β_i) 、velocity (tangential ν_{Wti}, side ν_{Wsi}, radial ν_{Wci}), acceleration(tangential a_{Wti}, side a_{Wsi}, radial a_{Wci}), the wheel Dynamic load of vehicle DLP L_i, the whole load ΣL_i，the wheel braking force F_{bi} of vehicle BPP, and balance and the whole braking force ΣF_{bi} are the parameters that can be measured by the proposed monitoring model.

Based on the analysis above, 27 items were selected to reflect the necessity of vehicle operating safe state monitoring entirely, truly, dynamically.

3. The framework of vehicle operating safe state monitoring platform based on WEIS

The wheel is the main part that contacts the road when vehicle works. By entirely monitoring 11 items of wheel MAP parameters it can be obtained that the most direct、true、abundant vehicle safe operating information. Based on wheel embedded intelligent sensors WEIS, it is likely to get the vehicle safe operating parameters of vehicle moving attitude MAP、dynamic load DLP、braking characteristic BPP. The following continue to analyze the relevance among monitoring parameters of vehicle safe operating and research on the principle framework and function of platform monitoring WEIS vehicle safe operating.

3.1. Analysis of relevance among monitoring parameters

The above has given that safety parameters must include 27 items of specific parameters. The following will give the analysis of relevance of these parameters, expecting to find the original physical variation which is essential for obtaining these parameters. Minimizing unnecessary、repeated measurement to reach the goal of sharing the information.

The monitoring of the vehicle body is relatively independent unit, of which the core is model of vehicle body MAP monitoring. By installing some intelligent three dimensional acceleration sense units on the vehicle body, calculating from the vehicle body monitoring model we can get all the MAP information. so the physical sensor of the vehicle body MAP monitoring should be some vehicle body three dimensional acceleration. All monitoring on the wheel MAP come from the wheel and is also relatively independent unit. By installing a intelligent three dimensional acceleration unit on hub for vehicle wheel, calculating from monitoring model of the wheel MAP we can get all the MAP information. So the physical sensor of the wheel MAP monitoring should be three dimensional acceleration on every wheel hub[3].

The wheel dynamic load L_i has a direct connection with the vehicle moving attitude parameters. With the help of vehicle MAP information and one installed intelligent three dimensional acceleration unit information of every hang system, from monitoring model of the wheel DLP, we can obtain all the wheel dynamic L_i and the whole vehicle ΣLi. To get the wheel dynamic load Li, two additional monitoring quantity are needed for a three dimensional acceleration of every hang system[4].The real-time pressure Pi、temperature Ti must depend on wheel hub integrated temperature and pressure sensor to get information.

Vehicle BPP includes these two information parts which are the wheel BPP and the whole vehicle BPP.

The slip rate、the braking force originated from the braking system and balance parameters of wheel I of wheel BPP can be obtained from calculating the wheel BPP monitoring model with the direct help of the MAP information and DLP information of the wheel, correspondingly the whole braking force ΣFbi can also be calculated. Therefore, we can get vehicle BPP information with the help of the MAP information and DLP information of the wheel, with no need to add additional monitoring sensor quantity [5].

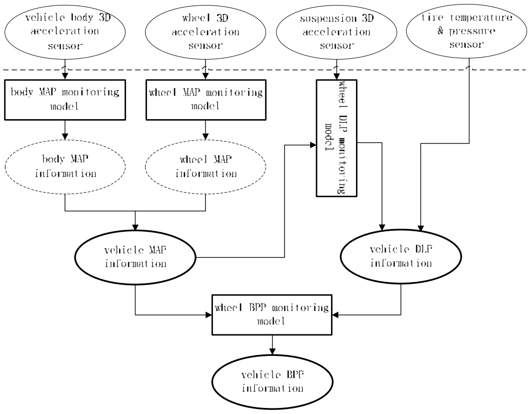

Fig. 2 Monitoring parameters of vehicle safely working and the information connection between sensor quantity

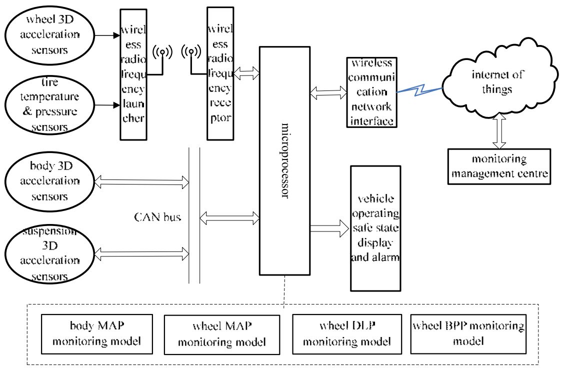

Fig. 3 Architecture of vehicle safety monitoring platform based on WEIS

It can concluded that physical sensor quantities which are essential for reaching the goal of monitoring vehicle safely working, are as follows. ①several vehicle body three-dimensional acceleration(put forward by the vehicle body MAP monitoring) ②three-dimensional acceleration, integrated pressure and temperature sensor on every wheel hub(put forward by the wheel body MAP monitoring) ③one three-dimensional acceleration on every suspension system(put forward by the wheel dynamic load Li). Based on these sensor quantity, with the help of the model of monitoring the vehicle body MAP monitoring, the model of the wheel MAP monitoring, the model of the wheel DLP monitoring and the model of the wheel BPP monitoring, associate the vehicle MAP, DLP and BPP information and calculate them out. Fig. 2 shows the monitoring parameters of vehicle safely working and the information connection between sensor quantities.

According to the analysis above, the relation between monitoring parameters in vehicle operating safety state has the following characteristics. ①It should reduce some unnecessary repetitive physical sensing parameters and obtain other parameters that traditional systems cannot detect because of the closed relationship between different parameters; ②For the case that the original circuits of vehicles have not been changed, it can form a relatively complete vehicles safety monitoring platform independent with other equipment relatively. If the information terminals connect with networking, such information can be more widely used.

3.2. Architecture of vehicles safety monitoring platform based on WEIS

Fig. 3 is the architecture of vehicles operating safe monitoring platform based on WEIS.It can be seen from the figure, the monitoring platform of vehicles operating safe state based on WEIS mainly consists three parts, including physical sensing information acquisition, information integration and processing, network of monitoring information terminals and its application.

As for physical sensing information acquisition, acceleration sensors, temperature sensors and pressure sensors equipped on the wheels aim to get the signals of three dimension accelerations, tire temperature and pressure, and establish communication with microprocessors by way of radio frequency transceiver; several three dimension acceleration sensors installed in the vehicles body and in the suspension system detect the information of acceleration, and communicate with microprocessor through CAN bus to complete gaining sensing information.

In the information integration and processing part, based on the amount of all physical sensor, the microprocessor calculates the vehicle MAP, DLP and BPP through body MAP model, wheel MAP model, wheel DLP model and wheel BPP model.

In the terminal network and application of the monitoring information part, on one hand the vehicle MAP, DLP and BPP information was displayed on the display terminal through the vehicle security alarm system for motor vehicles operating, on the other hand, the safe operation status information of motor vehicle was transmitted to other monitoring systems and management canter through the wireless communication network interface, for further application.

4. Conclusion

(1) The vehicle safety state monitoring must include three key parameters of MAP, DLP and BPP. The body MAP can evaluate the overall vehicle rolling danger; wheel MAP can evaluate imbalance, loose, flying off danger of the wheel; DLP reflects whether the dynamic load exceeds the rated load, tire pressure and temperature in a safe condition and the loading of the vehicle runs well; BPP reflects the braking performance of the vehicle.

(2) The movement posture MAP, dynamic load DLP and braking performance BPP three critical parameters proposed in this paper, includes 27 specific evaluation indicators, which can reflect the safe operation state of motor vehicles truly and dynamically, more comprehensive and scientific than ever.

(3) The relationship between the information of MAP, DLP and BPP is established. The amount of vehicle safe operation physical sensor is analyzed, in the condition of reduction of the unnecessary amount of physical sensor, to get some parameters that can't be measured by traditional measurement. Then a relatively complete and relatively independent vehicle safety warning monitoring platform can be formed. If the formed information terminal can access to internet of things, it will be more widely used.

Acknowledgements

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