Research on Inspection Method of Dynamic Load of Truck by Using EWT

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ABSTRACT

The article provides a new method for dynamic real-time detection of vehicle loads, and a useful technical reference for further improving the driving safety of the vehicle. The dynamic monitoring of vehicle load is of great significance to stable driving. In order to resolve this problem, we present an algorithm that can calculate vehicle load on the basic of empirical mode transform (EWT) and a corresponding vehicle load dynamic testing platform. The relationship between the vehicle load and the suspension variables is the foundation of realizing load detection. To obtain it, we establish a two-degree-of freedom suspension dynamic model and analyze the dynamic characteristics of the suspension under various vehicle speeds and loads. We design a dynamic load detection device with overload protection to collect the dynamic signal of vehicle. The data processing algorithm of the vehicle load dynamic detection device is constructed based on EWT. In order to verify the effectiveness of the device, a model truck is taken as the test vehicle. Based on the DSP chip, the vehicle load dynamic testing platform is developed. In order to test the accuracy of the system, the calculation accuracy of the system is tested with different load at different speeds. The experimental results show that the system exhibits a high accuracy in the measurement experiment.

KEYWORDS

Dynamic Detection, Empirical Wavelet Decomposition, Truck, Vehicle Engineering, Vehicle Suspension

INTRODUCTION

The loading state of the vehicle has a significant impact on vehicle stability. On the fundamental of the load distribution, the vehicle can be controlled, which can effectively enhance the stability of the operation (Baykasoglu et al., 2013; Golas et al., 2013). Therefore, the real-time on-line monitoring of the dynamic load status and early warning can effectively reduce the probability of traffic accidents that occur due to the abnormal loading state of the vehicle as running (Faulin et al., 2011; Hirsch, 2013; Malairajan et al., 2013).

At present, few researches have been done on the method of load dynamic detection. The BP neural network method was used to identify the dynamic load of the air suspension system, but the calculation accuracy is not ideal (Yang et al., 2010). Chen et al., (2011) designed a paste-based strain sensor vehicle overload monitoring system, but the vehicle load detection sensor structure was complex and at high cost, so the practicality is poor. Based on optical fiber sensor, a kind of vehicle

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load calculation strategy was designed (Yuan et al., 2005). Niedzwiecki et al., (1996) studied the application of adaptive filtering in vehicle dynamic weighing. The key of the dynamic load detection is the extraction of dynamic and static loads, which has not been studied in detail.

After the proposal of the empirical mode decomposition (EMD) method, it has been widely applied in the field of signal processing due to self-adaptability of decomposition (Flandrin et al., 2004; Liu et al., 2016; Liu et al., 2006; Xun et al., 2008; Loutridis, 2004; Loh et al., 2001; Balocchi et al., 2004; Lei et al., 2013; Flandrin et al., 2004). The published literature (Huang et al., 1998) has been quoted more than 15000 times in Google Scholar. In order to solve the mode mixing problem, Wu et al., (2009) proposed the ensemble empirical mode decomposition (EEMD). Complementary ensemble empirical mode decomposition (CEEMD) method (Yeh et al., 2010) can reduce the calculation error due to added white noise; and therefore, this method was widely noted in practical engineering problems (Tang et al., 2015; Li et al., 2014; Li et al., 2015; Jallon et al., 2013). Hereafter, Complementary ensemble empirical mode decomposition with adaptive noise (CEEMDAN) was proposed in order to improve the algorithmic efficiency and had a quicker calculation speed (Torres et al., 2011). As the noise is added self-adaptively, the ideal decomposition results can be obtained after few times of iterations. This method is also applied in the biological and mechanical fields (Li et al., 2014; Hassan et al., 2015; Navarro et al., 2012; Lei et al., 2015; Humeau-Heurtier et al., 2015; Jimenez et al., 2014; Wu et al., 2014; Sadek et al., 2015; Cui et al., 2015; Loomis et al., 2014).

In general, as the existing EMD method is a basic self-adaptive method, the decomposition primary function is generated according to its own features so that the decomposition result is highly flexible, which is beneficial to the extraction and separation of the signals. However, a mass of iteration screening process will cause a mass of calculation quantity. High time-frequency resolution of continuous wavelet transform is established on the basis of flexible selection of wavelet basis. However, analysis on signal features is done on the time-frequency plane. On the time-frequency plane, the signal frequency distribution and the relative strength of each frequency as time changes can be observed. However, each component of signal in the time domain cannot be separated and extracted. This operation can be implemented with a decomposition method similar with EMD.

Empirical wavelet transform (EWT) is a new self-adaptive signal processing method proposed by Gilles (2013) in 2013 combining the wavelet transform theory and EMD method. The core concept is to slice the spectral self-adaptively to form a series of band pass filters with appropriate band widths, in order to extract a frequency and amplitude modulation with the compact support spectral features. This algorithm combines the advantages of EMD method and wavelet transform method, therefore this method has been widely used so far (Kumar et al., 2014; Jiang et al., 2016; Pan et al., 2016; Merainani et al., 2015; Liu et al., 2016; Hu et al., 2015; Singh et al., 2015). Static load can be deemed as the trend component in the load vibration signals, dynamic load as vibration component. In order to separate the dynamic and static loads, EWT is introduced in this paper for separation and extraction of load vibration signal.

According to the background knowledge on automobile theory, suspension is the component supporting the suspending structure of the whole vehicle. The main function is to transmit the force and moment of force between the tire and the frame, alleviate the compact of pavement unevenness on vehicles, and attenuate vibration of the vehicle. In order to dynamically inspect the load of the vehicle, dynamic mechanical property of the steel plate spring suspension is simulated and analyzed. Based on the analysis results of the relationship between the vehicle load and the suspension steel plate spring transformation, a vehicle load dynamic inspection device with high-precise overload protection is designed. A vehicle load inspection dynamic system test platform is established on the basis of EWT method.