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Research On Dynamic Inclination Monitoring Method Based On Acceleration Measurement And Kalman Filtering

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A structure that is in a vibration state contains multiple degrees of freedom such as translation and rotation. When we observe the structure, we are accustomed to adopting the translational degrees of freedom, such as using acceleration sensors or displacement sensors to measure vibration parameters in the translational direction, while the rotational vibration by means of inclination observation is generally ignored. Compared with translation, rotational observations are more global and more sensitive to the vibration characteristics of structures. Therefore, it is necessary to carry out rotational vibration observations and provide a dynamic monitoring method for rotational degrees of freedom. In view of this, this paper firstly demonstrates the necessity of rotational degree of freedom monitoring and discusses the effectiveness of rotational monitoring in multiple application scenarios such as structural condition assessment. Secondly, this paper establishes a dynamic inclination measurement model on the basis of the existing static inclination measurement by the acceleration sensor, and respectively constructs the state equation and measurement equation that comprehensively characterize the translational and rotational degrees of freedom. Thirdly, this paper adopts the extended Kalman filtering method to realize the linearization and discretization of the state equation and measurement equation. Finally, this paper deduces the filter calculation formula of the dynamic inclination angle. A specific example of a single-beam structure is established to verify the reliability of the dynamic inclination measurement method. Using the numerical simulation method, the mass, stiffness, and damping matrices of the single-beam structure in the translation direction and the rotation direction are constructed, and the external loads and noises are superimposed to calculate the dynamic response in the translation and rotation directions respectively, and further yields measurement of the acceleration. Taking the measurement of acceleration as input, the dynamic inclination monitoring method derived in this paper is adopted, and the dynamic inclination angle in the rotational direction is obtained by filtering. By comparing the estimated value of the dynamic inclination angle and the simulated value of the numerical simulation, it is verified that the method has high accuracy in the time-domain, and can accurately realize the separate measurement of translational vibration data and rotational vibration data. On the basis of the time-domain signal comparison, this paper further compares the estimated values with the simulated values in the frequency domain, and the comparison results show that the level of similarity is high. The signal-to-noise ratio of external load and noise, as well as the adjustment of the amplitude of external load, prove that the method studied in this paper has better performance when the external load signal-to-noise ratio is high and the dynamic angle response is small. That is, the method is suitable for structures with large loads and high stiffness, such as bridge structures carrying heavy traffic loads.