applied sciences

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Editorial

Special Feature Vibration-Based Structural Health Monitoring

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Received: 22 July 2020; Accepted: 22 July 2020; Published: 27 July 2020

1. Introduction

Structural health monitoring by vibration requires the understanding of multidisciplinary fields of engineering sciences. Since vibration behavior is influenced by structural properties, their analysis requires consideration of the excitation mechanism, vibration energy transfer and subsequent dissipation. For efficient monitoring, the relevant signal processing is crucial for cost-effective and reliable identification. Although the use of vibration for structural integrity monitoring is complex, its potential to be used for a wide variety of engineering fields is continuously increasing. The studies on the application of machine learning to the classification of vibration-based monitoring are being proposed by many research groups as summarized in the review [1]. To anticipate unexpected failure and estimate remaining life time with actual implementation, continuous vibration monitoring together with statistical feature extractions are important. The proposed Special Issue was intended to collect recent advances on the use of vibration for structural health monitoring. The studies show application fields with their potential to be expanded to a wide variety of machines and infrastructures.

2. Vibration Analysis of the Complex Dynamic Systems by Numerical and Experimental Approach

For the application of vibration analysis to system identification, direct methods analyzing responses from external loads are preferred. Frequency response analysis for vibration prediction of perforated shells was performed for application to statistical modeling techniques and to be used for damage detection [2]. Damage detection using modal rotational mode shapes was proposed [3]. The vibration mode shapes were measured from the responses detected by a laser Doppler vibrometer. For measurements of ground vibration, the influence of geometric parameters of the measuring base was investigated numerically [4]. The normal modes were calculated to identify vibration interactions. For the vibration analysis of sprag-slip oscillation, a minimal nonlinear dynamic model with a variable angle of the inclined spring was proposed [5]. This provided information about vibration characteristics of a frictional sliding system.

Yoshida et al. [6] proposed a simple discrete model to understand the random fluctuation arising in human–bicycle motion. Probability density functions were used to evaluate the vibration responses. Opazo-Vega et al. [7] proposed a experimental method to estimate damping of lightweight timber floors. Damping is an important parameter to be identified accurately. Li et al. [8] presented dynamic responses of supertall buildings exposed to severe typhoons. The vibration responses were recorded for structural health monitoring. Orvañanos-Guerrero et al. [9] proposed a four-bar mechanism reducing the force transmitted through the base of the operating machine. The reduction of vibration is important to reduce vibration fatigue and increase the accuracy of the vibration-based system identifications. Bedon and Fasan [10] evaluated the dynamic performance of an in-service glass walkway. The vibration comfort was assessed based on experimental estimates. The pedestrian's perception depended on the ambient vibration responses of the structure.

3. Sensors, Parameter Identification, and Signal Processing

Feature extraction taking into account the influence of surrounding environments and ambient operation conditions is required to increase the accuracy of diagnosis. Wang et al. [11] presented the effects of temperature on the vibration monitoring of concrete slab structures. Experiments were performed to find the influence of temperature on modal properties used for damage diagnosis. Jeong and Jeong [12] proposed an optimization method for sensor batch design to measure roughness on railhead surfaces. This information allowed the estimation of corrugations and contact between wheel and rail during train operation to analyze rolling noise. The variation of the rolling noise magnitude is an important feature showing the current rail status. Feng and Wu [13] identified the possible defects in gas-insulated switchgear using vibration amplitude for diagnosis of a power grid. The periodicity in the vibration responses was used to extract the vibration feature. Toh et al. [14] investigated the measurement method of the clamping force from the bolt vibration responses. This allowed indirect monitoring of the bolt tightening process without the use of load cells, which is advantageous for application to the manufacturing process.

Zhang et al. [15] proposed a weighted Morlet wavelet-overlapping group sparse algorithm for rolling bearing fault diagnosis. The impulse feature was identified to analyze the possibility of faults. Yan et al. [16] applied variational mode decomposition to diagnose rotor faults. The patterns of time-varying frequency components were identified accurately. Madan et al. [17] investigated an adiabatic fiber taper structure inscribed using femtosecond laser micromachining. The proposed sensor allows health monitoring of arbitrary civil structures with accurate strain measurements. Lee and Song [18] proposed an adaptive Kalman filter to identify damage using sparse vibration measurements. The filter efficiency was validated by numerical investigations.

Lin and Chen [19] proposed a data processing system for structural health monitoring by analyzing ambient vibrations. The accuracy was validated by locating damage in the scale-down benchmark structure. Tang et al. [20] estimated parameters to understand the vibration of a testing structure. The algorithm allowed consideration for nonlinear responses and uncertainties. Shi et al. [21] proposed modal frequency sensors to reduce interference in settlement surveillance monitoring of steel transmission towers. The numerical analysis was used for verification of the efficiency and robustness of the Kriging surrogate model. Tsunashima [22] proposed a condition monitoring system for real-time inspection of regional railway lines in Japan. The car body vibration was predicted and used for feature extraction by machine learning algorithm.

4. Expectations

This Special Issue included the recent research activities of vibration-based structural diagnosis methods as summarized. As presented in the contributed works, vibration-based health monitoring requires considerations of numerical and experimental analysis, measurements, sensors, signal processing, and excitation mechanisms. With its applications in a wide variety of systems, the research outcomes in the relevant future investigations will contribute to ensuring safe, quiet, and reliable spaces for engineering structures.

Funding: This research received no external funding.

Conflicts of Interest: The author declares no conflict of interest.

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