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Smart Indirect Damage Detection Of Bridges Considering Operational Effects Through Mel-Frequency Cepstral Coefficients Using Inverse Filtering Method

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This paper puts forward a drive-by damage detection approach for bridges using smartphones considering operational effects. The most challenging aspect of indirect bridge monitoring is the fact that the vibrations recorded on the vehicle is significantly affected by operational sources, such as vehicle and road roughness. Recently proposed inverse filtering methodology is focused on removing those effects to amplify bridge dynamic features. The methodology employs off-bridge vehicle vibrations to design a filter capable of suppressing operational effects. In addition, an abnormality index is introduced based on the difference in the distribution of Mel-frequency cepstral coefficients between the healthy and unknown bridge conditions. The successful performance of the inverse filtering methodology in eliminating operational effects from the abnormality index is assessed under controlled laboratory and real-life conditions. It is shown that without applying the inverse filtering method, the abnormality index is not an appropriate representative of the bridge state. The capability of the proposed abnormality index in detecting damage on the bridge is evaluated through a series of laboratory experiments with different damage levels and locations. The results corroborate the fact that the vibrational data collected by smartphones of the passengers are reliable for bridge damage detection. Consequently, through a crowdsensed framework, it would be possible to monitor a large population of bridges without installing fixed sensors, which is economically efficient and toward the perspective of a more sustainable and resilient infrastructure management in future smart cities.