Deflection Estimation Of Highway Bridges Based On Acceleration Measurement Using A Machine Learning Approach

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Deflection of a bridge is an important physical quantity for the performance monitoring of a bridge and is used for bridge weigh in motion (BWIM) systems. Deflection sensors such as Laser Doppler Velocimeter (LDV) and Linear Variable Differential Transformers (LVDT) are accurate, but these sensors need fixed reference points which are difficult to find. On the other hands, the wireless MEMS accelerometers are easy to install and an economical field measurement system. Numerical double-integration and Kalman filter approaches can estimate displacement from acceleration data. However, in the case of acceleration data with low-frequency components corresponding to multiple vehicles' passing in series, double-integration is not applicable due to cumulative numerical integration error. On the other hand, Kalman-filter approaches combine vertical acceleration and inclination calculated from longitudinal accelerations and avoid numerical integration error. However, the Kalman filter approaches have the limitations in the application to highway bridges where vehicles move with high speed. The passage of high-speed vehicles results in longitudinal motion of girders and influence the inclination measurements. In this paper, a machine learning approach is used to overcome this longitudinal influence due to high-speed vehicles and to accurately estimate the bridge deflection not only for high-speed vehicle over the highway bridges but also for multiple vehicles passing in series causing long-period deflection components. The method uses only acceleration measurement even for training data generation and results in high accuracy. The estimated deflection is also validated using Sampling Moire Camera (SMC) technique.