Data-Driven Modeling Of Bridge Vortex-Induced Vibration Via A Physics-Guided Machine/Deep Learning Framework

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Vortex-induced vibrations (VIVs) have been observed on long-span bridges worldwide. Classic semi-empirical VIV models that depend on wind tunnel tests are challenged when applied to real bridges due to the complexity of real natural winds, high Reynolds number effects, and uncertainty of bridge structures. The prediction accuracy of these laboratory-based models may, thus, be reduced for real large-scale bridges. Emerging field monitoring systems on prototype bridges allow one to rethink about modeling of bridge VIVs with unprecedented considerations of real natural winds and full-scale structures by leveraging the accumulated data of the real-time monitoring. This work presents a physics-guided machine/deep learning framework for modeling bridge VIVs with field monitoring data. Specifically, we incorporate Scanlan's semi-empirical VIV model as the prior physical knowledge to guide the machine/deep learning of bridge VIV dynamics. We demonstrate the presented framework on a real long-span bridge with a field monitoring system. We show that the obtained data-driven models can predict VIV response history under real natural winds that can be nonstationary and nonuniform. Also, the data-driven models can be used for the identification of the VIV wind speed ranges. The limitation of this work and the potential future work are further discussed.