Machine Learning-based Structural Health Monitoring and Condition Assessment for Long-span Bridges

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Abstract

Machine learning (ML) provides a promising paradigm for discovering and modeling structural performances and conditions through the deep mining of structural health monitoring data. This paper exhibits recent progress of ML-based structural health monitoring and condition assessment for long-span bridges. A series of novel algorithms for bridge condition assessment via correlation modeling between structural responses, computer vision-assisted structural damage detection, and data mining for wind effects are introduced. First, correlation modeling between different bridge responses is investigated by both the time series data and probability distribution, further assisting bridge condition assessment. Second, several novel CNN architectures and a few-shot meta-learning framework are also established for CV-assisted bridge damage detection. Third, wind-induced vibrations of the bridge in site are identified and modeled to predicate structural responses and evaluate operation conditions. Results show that ML techniques indeed improve the state of the art in structural health monitoring and condition assessment for long-span bridges.

Keywords: machine learning; deep learning; computer vision; structural health monitoring; condition assessment; long-span bridges.

1 Introduction

Nowadays, structural health monitoring (SHM) systems are widely implemented on large-scale cable-stayed bridges and utilize various sensors to monitor structural responses and environmental factors [1], e.g., girder vertical deflection (GVD), cable tension (CT), temperature, etc.

Bridge structural condition assessment is one of the most significant issues in SHM. Conventional structural condition assessment usually compares statistical values of monitoring data with pre-designed thresholds as criteria. However, this straightforward approach is often inaccurate and inappropriate for real-world applications. The structural response is definitely coupling-influenced by both the structural mechanical model and external loads, whereas it is difficult or even impossible to precisely obtain them. Therefore, it is still difficult to directly perform condition assessment from variations of structural responses because of the unknown initial residual stress and defaults, and coupling effects of structure damage and external loads.

With the recent booming development of artificial intelligence and big data algorithms, data-driven

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