A machine learning-based methodology of integrating loading data and load effect data for long span bridge assessment

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Abstract

A number of long span bridges around the world have extensive structural health monitoring (SHM) systems installed. These bridges are complex structures under complex operational and environmental conditions, making it challenging to process and interpret the monitoring data obtained. This paper presents a machine learning (ML)-based methodology of linking bridge loading data with measured load effect data for long span bridge assessment, developed using the monitoring data obtained from the 1377 m main span Tsing Ma Bridge in Hong Kong. The proposed methodology includes supervised, unsupervised and semi-supervised learning techniques to enable and automate the identification, classification and segmentation of different live load effects. The developed methodology can assist with more realistic load rating and fatigue assessment and facilitate the operation and maintenance (O&M) of long span bridges.

Keywords: long span bridge; structural health monitoring; machine learning; traffic loading; load effect; load rating; fatigue assessment.

1 Introduction

A number of the world's landmark long span bridges, such as the Tsing Ma Bridge (TMB) and Stonecutters Bridge (SCB) in Hong Kong and the Queensferry Crossing (QC) in Scotland, have extensive Wind and Structural Health Monitoring Systems (WASHMS) developed and deployed [1,2]. These were installed at the start of the bridges' service life in the hope that they will provide useful information on real structural condition and performance in order to improve bridge operation and maintenance (O&M) and facilitate intelligent asset management.

Long span bridges are complicated structures under complex operational and environmental loading conditions, which results in even more complex structural behaviour and structural responses. This makes it challenging to process and interpret the monitoring data obtained from these bridges. Therefore, it remains an asset management challenge to utilise the monitoring data collected from these bridges in order to inform their structural assessment and maintenance.

To enable more realistic structural assessment of bridges, the following are needed: (i) understanding the real loading conditions (e.g., traffic loading [3], wind loading [4]); (ii) understanding the real structural behaviour and structural responses (e.g., traffic load response [5,6], wind response [4]); and (iii) linking measured bridge loading data with measured load effect data for assisting with load rating and fatigue assessment [5,7]. However, (ii) and (iii) are

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