Data-driven structural condition assessment for highway bridges under operational environments

by Ye Yuan

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under the supervision of

A/Professor **Xinqun Zhu** and Dr **Jun Li**

University of Technology Sydney
Faculty of Engineering and Information Technology (FEIT)

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CERTIFICATE OF ORIGINAL AUTHORSHIP

I, **Ye Yuan** declare that this thesis, is submitted in fulfilment of the requirements for the award of Master of Engineering (Research), in the School of Civil and Environmental Engineering at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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Signature: Production Note: Signature removed prior to publication.

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TABLE OF CONTENTS

ABSTRACT

Bridges are key transportation infrastructure. In Australia, over 60% of bridges on local roads are over 50 years old. With the deterioration of the bridge performance and ever-increasing amount of traffic, the bridge safety is becoming a concern for engineering community. A method that can assess the bridge's condition in real-time is urgently needed. Structural health monitoring (SHM) provides a practical tool to assess and predict the condition of bridges. From the perspective of the real-time monitoring, the main factor that hinders an ideal bridge condition assessment is the uncertain operational environment. Existing SHM methods either try to assess the structural performance under the controlled environmental conditions or eliminate the influence of the operational environment using long-term monitoring data to train or calibrate the condition assessment model. These two ideas cannot fit the target of the real-time monitoring.

To achieve the real-time monitoring, this study proposes a new damage sensitive feature (DSF) based on moving principal component analysis (MPCA). The two main operational environmental factors: environmental temperature and traffic loads, are studied in the assessment process to verify the robustness and practicality of the proposed DSF. The numerical and experimental study has been carried out to show the reliability and accuracy of the proposed method. The mechanism of the DSF variation induced by changes in environmental parameters are discussed to show the interpretability of the proposed DSF. The value of the DSF can precisely reflect bridge's overall vibration 'rhythm' which is reliable to reflect the bridge's instantaneous vibration state. This DSF is not restricted to several few pre-considered parameters but reflects the bridge's damage condition from a dynamic perspective.