Aerodynamic Parameter Identification and Flutter Performance Prediction of Closed Box Girder Based on Machine Learning

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Abstract

A bridge wind resistance database has been built based on the wind tunnel testing results of 20 long-span bridges. The artificial intelligence models for identifying aerostatic coefficients and flutter derivatives of close box girders are trained and developed via machine learning methods, including error back propagation neural network based on Levenberg-Marquardt algorithm and gradient boosting decision tree. The identification of the aerostatic coefficients can be achieved with high accuracy. For flutter derivatives, the model can also explore the underlying distribution of dataset. In this way, the present research work can make the identification of aerodynamic parameters separated from tedious wind tunnel test and complex numerical simulation to some extent. It can also provide a convenient and feasible option for expanding data sets of aerodynamic parameters. In addition, it can help determine the appropriate shape of the box girder cross-section in preliminary design stage of long-span bridge and provide the necessary reference for the aerodynamic shape optimization by modifying local geometric features of the cross-section to evaluate the influence of the aerodynamic shape on flutter performance.

Keywords: long-span bridge; closed box girder; machine learning; aerodynamic parameter; flutter performance.

1 Introduction

With the increasing span of bridges, bridges are characterized by light weight, high flexibility and low damping, making wind-resistance a key control factor in structural design. Aerodynamic parameters are important for describing the wind-resistance of bridges. They play a vital role in the analysis of static wind stability, flutter, galloping, vortex-induced vibration and buffeting. At present, the aerodynamic parameter identification methods of bridges are very mature, and all parameters can be obtained by wind tunnel test or numerical simulation. As the most effective and reliable means of wind-resistant design of bridges, wind tunnel test has the problem of high cost, and it can only be analyzed for a specific cross-section. The experimental results are not universal. With the advancement of computer technology, the numerical simulation developed rapidly, but its calculation accuracy still needs to be verified.

In recent years, machine learning methods have been widely used in the field of bridge and structural wind engineering, such as wind environment prediction, aerodynamic shape optimization, wind-induced effect simulation and aerodynamic parameter identification. Fu J.Y. made use of fuzzy neural network to predict the wind load on the long-span roof surface [1]. Xie Z.N. applied a 3-layer back propagation neural network to identify the wind-induced interference

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