Bridge Performance Prediction Approach Based on Improved Particle Filter and Structural Health Monitoring Data

Guang Qu, Limin Sun

Tongji University, Shanghai, CHN

Contact:lmsun@tongji.edu.cn

Abstract

To reasonably and dynamically predict the performance of the in-service bridges, this paper proposes an adaptive-variance Bayesian-dynamic-linear-model Improved Particle Filter (IPF) prediction approach to reliability for bridge structures with sensor measurements. First of all, the adaptive-variance dynamic linear model, which provides state equation, monitored equation and initial state information for the PF, is built with the measurements of bridge sensors. The corresponding theoretical and numerical recursive processes are carried on with the Bayes method. Then the built adaptive-variance Bayesian-dynamic linear model is applied to provide the dynamic importance distribution functions for PF, which can solve the sample degradation problem of the traditional particle filter. Proceed to the next step, using the IPF prediction approach and FOSM method, structural reliability at critical points is dynamically predicted based on the sensor data. Finally, an actual bridge is provided to illustrate the feasibility and application of the proposed model and method.

Keywords: sensor measurements; performance; adaptive-variance dynamic linear model; the importance distribution function; structural reliability.

1 Introduction

Structural Health Monitoring (SHM) is a valuable technology to ensure the safety of civil infrastructures and achieve their sustainable management [1]. For the in-service bridges, structural safety is essential. The sensor data provided by SHM systems is a critical parameter in structural safety analysis and can be used to evaluate and predict structural dynamic safety reliability.

SHM has become the escalating urgent need for modern bridge engineering in recent years and has grown into a hot topic in investments and research worldwide. With the innovation of sensing data acquisition, SHM systems are comprehensively deployed and used to obtain the extreme stress data of the long-span bridge bridges in different sampling frequencies. Making reasonable use of sensor data for predicting the dynamic reliability of the existing bridge has been still in the initial research stage. Still, it has become one of the leading scientific problems in the BHM field.

Nowadays, Structural Health Monitoring (SHM) research mainly focuses on sensors-based data acquisition and sensor data application. The research about data acquisition mainly concentrates on data compression, data recovery, data acquisition technology, system assembly technique, and so forth [2-6]; currently, these researches have been mature in the hardware and

https://doi.org/10.2749/nanjing.2022.1329