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IASCM

7WCSCM

THE 7th WORLD CONFERENCE ON STRUCTURAL CONTROL AND MONITORING

July 22-25, 2018. Qingdao, China

PROCEEDINGS

Abstracts and Papers of

The 7th World Conference on Structural Control and Monitoring

7WCSCM

July 22-25, 2018

Qingdao, China

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Preface

Infrastructure is the basis for supporting the development of society. However, infrastructure typically suffers from harsh environment and natural disasters (e.g., earthquakes, wind), which may shorten the life-span and reduce the safety of infrastructure, further having substantial impact on sustainability of society. Structural monitoring and control are powerful and effective tools to make infrastructure have capability of early warning and control when their performance deteriorates or their safety is in danger, thus ensuring their safety and extending their life-span. In addition to the traditional monitoring and control technologies, artificial intelligence (AI) is one of most advance technologies at the present stage. The AI techniques will produce far-reaching revolution on traditional civil infrastructure, e.g., they can make intelligent infrastructure capable of seeing, hearing, sensing, monitoring, thinking, talking, adapting and controlling. It is therefore considered appropriate to bring together all of the best and cutting-edge work that has been exploited in the field of structural monitoring and control at the Seventh World Conference on Structural Control and Monitoring (7WCSCM), held in Qingdao, China from July 22 to 25, 2018. The precedent conferences have been held in Pasadena - USA (1994), Kyoto - Japan (1998), Como - Italy (2002), La Jolla - USA (2006), Tokyo - Japan (2010) and Barcelona - Spain (2014), respectively.

The International Association for Structural Control and Monitoring (IASCM), which serves as the organizing association of 7WCSCM, encompasses all aspects of structural control and monitoring for a variety of civil, mechanical, aerospace and energy systems. Specifically, it deals with smart sensing technologies, algorithms for damage detection, parameter identification and model updating, theories for condition assessment, safety evaluation and reliability analysis, structural control devices and systems, hybrid simulation and various testing technology, control algorithms, integration techniques of structural health monitoring systems, structural monitoring and control systems, and the practice of structural monitoring and control techniques. The objective of IASCM is to promote international cooperation in the fields of structural control and monitoring. The interest of the international community in all these fields has been confirmed by the active feedback on the call for papers. In fact, more than 500 abstracts were received at the Conference Secretariat and will be presented at the Conference within 6 keynote lecture sessions and 60 technical sessions.

7WCSCM covers all major aspects of structural control and monitoring, including smart control devices, control of bridges under earthquake or multiple hazards, seismic isolation, semi-active vibration control, flow controls for wind and structures, wind effects and wind-induced vibration control for large-scale structures, hybrid simulation and real-time hybrid simulation, hybrid testing methods, smart and multifunctional concrete, infrastructure inspection using unmanned aerial and ground vehicles, computer vision for structural monitoring and damage detection, computer vision-based sensing and system identification, computer vision-based structural health monitoring, practical estimation of structural displacement, strain-based structural health monitoring, dense arrays of sensors/distributed/quasi-distributed sensors/associated data analysis and management, sparse recovery technique in SHM, SHM with multi-data, structural system identification, algorithms for Bayesian inference and uncertainty quantification in SHM, uncertainty-involved structural model updating/damage assessment/reliability evaluation, vehicle-bridge interaction and applications in bridge weigh-in-motion (BWIM)/damage detection/bridge management, monitoring-based performance assessment of infrastructure, monitoring-based life cycle assessment of infrastructure, monitoring-based bridge condition assessment and safety warning, system integration/SHM application/structural performance assessment, understanding/mitigating/utilizing human-induced structural responses, application of SHM techniques, highway infrastructure monitoring, SHM for long-span bridges, bridge automatic monitoring and intelligent construction of high-speed railway, structural monitoring and control of high-speed railway, structural control and monitoring of wind turbine structures, advanced sensing technology, recent research advances on structural control and health monitoring in Australia, recent development and future trend for research and application of structural control in China, research advances in SHM: Chinese experiences and application/research and design on structural control in Japan.

Package of Structural Control and Monitoring encompasses the lectures and papers presented at 7WCSCM. It consists of a book of abstracts and a USB flash disk containing the full papers of the lectures presented at 7WCSCM, including seventeen Keynote Lectures, more than five hundred technical papers from eighteen countries and Kobori prize winners. It provides both an up-to-date overview of the field of structural control and monitoring, and the cutting-edge and future trends in this field.

On behalf of IASCM, the chairs of the Conference would like to take this opportunity to express their sincere thanks to the authors, organizers of special sessions, and participants for their special contributions, to the members of the IASCM Advisory Committee, Conference Scientific Committee for their dedicated work, and to the members of the Organizing Committees for the time and effort they have dedicated to make 7WCSCM a successful event. Finally, we would like to register our sincere thanks to all of the sponsors of 7WCSCM.

Hui Li
Chair, 7WCSCM
Qingdao, July 2018

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Keynote Lectures

The 7th World Conference on Structural Control and Monitoring, 7WCSCM,
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Bayesian Framework for System Identification and Structural Health Monitoring: Theory, Algorithms and Applications

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Abstract

SI (system identification) methods may be used to update a parameterized model of a structure based on features extracted from its measured vibrations such as modal parameters. A common goal in applying SI to SHM (structural health monitoring) is to infer damage-induced substructure stiffness reductions by updating stiffness parameters in a structural model. However, since no structural model is an exact representation of a structure's behavior, (i) there are no true parameter values, and (ii) an uncertain model prediction error will always exist. Further, parameter estimation often gives non-unique results, raising the issue of model identifiability. A Bayesian framework has been developed that addresses these difficulties. It views probability as a multi-valued conditional logic for quantifying plausible reasoning under uncertainty. In this framework, there is no need to postulate the existence of inherent randomness. Instead, the relative plausibility of each model in a parameterized model class is quantified by the posterior PDF (probability density function) for the model parameters coming from Bayes' Theorem. Then model predictions that are robust to modeling uncertainty can be produced where the probabilistic predictions of all models in the model class are integrated weighted by their posterior probability. Many computational tools have been developed to sample or approximate the posterior PDF and to perform integrations over the parameter space. Another powerful feature of the framework comes from application of Bayes' Theorem to a set of candidate model classes for a structure; the posterior probability of a model class is governed by a trade-off between its data-fit and how much information it extracts from the data during updating. Generally, the data-fits of model classes that are more "complex" in the sense of having more adjustable parameters are penalized more, so the procedure is a Bayesian version of the Ockham razor that can automatically avoid over-fitting of the sensor data. This regularization is utilized in Sparse Bayesian learning (SBL), which can be exploited for robust Bayesian compressive sensing of SHM signals. We have also introduced SBL into Bayesian SI for improved damage detection and assessment by exploiting the knowledge that damage usually induces spatially-sparse substructure stiffness reductions. Illustrative examples will be given.

Keywords: System Identification, Structural Health Monitoring, Bayesian Updating, Bayesian Ockham Razor; Sparse Bayesian Learning.

1 Introduction

System identification is the key component in model-based inversions for detection and assessment of damage in structural health monitoring. It uses observed structural response data and prior knowledge to update mathematical models of the behavior of a system such as a bridge