# Accepted Manuscript


Development of sensor validation methodologies for structural health monitoring: a comprehensive review

Ting-Hua Yi, Hai-Bin Huang, Hong-Nan Li

PII: S0263-2241(17)30371-8
DOI: http://dx.doi.org/10.1016/j.measurement.2017.05.064
Reference: MEASUR 4790

To appear in: *Measurement*

Received Date: 28 November 2016
Revised Date: 23 May 2017
Accepted Date: 26 May 2017

Please cite this article as: T-H. Yi, H-B. Huang, H-N. Li, Development of sensor validation methodologies for structural health monitoring: a comprehensive review, *Measurement* (2017), doi: http://dx.doi.org/10.1016/j.measurement.2017.05.064

# Development of sensor validation methodologies for structural health monitoring: a comprehensive review

Ting-Hua Yi[1,*], Hai-Bin Huang[1], and Hong-Nan Li[1,2]

1. School of Civil Engineering, Dalian University of Technology, Dalian 116023, China;
2. School of Civil Engineering, Shenyang Jianzhu University, Shenyang 110168, China.

## ABSTRACT

Sensor faults, which occur when sensor outputs display unacceptable deviations from the true values of measured variable, will cause false alarms and missed detections in structural health monitoring (SHM) systems. The study about sensor validation is a relatively new research direction in the SHM field and it is meaningful to guarantee the accuracy and reliability of health-condition evaluations for monitored structures. This paper provides a comprehensive review of current research and development activities in sensor validation methodology for SHM. At first, seven typical sensor fault types are described and a detailed methodology categorization is provided. Following that, the progresses on sensor validation, which mainly focusses on the detection, isolation and reconstruction of sensor faults, are reviewed based on the categorization. Finally, concluding remarks and promising research efforts about sensor validation are summarized in detail.

*Keywords*: Sensor validation; Fault detection, isolation and reconstruction; Structural health monitoring

## 1. Introduction

Nowadays, there are more and more large-scale civil structures, e.g., tall buildings and long-span bridges, being constructed [1]. Damage of these civil structures will inevitably occur over their long-term service period, and their performance will also deteriorate due to material fatigue, environmental corrosion and ambient loads [2-5]. Structural health monitoring (SHM), which aims at continuously monitoring structural behavior, identifying structural damage at an early stage, and evaluating structural performance in real time, has been suggested as an important research direction in civil engineering area [6, 7]. SHM can be adopted in newly constructed or existing civil structures to understand the current health conditions, prevent catastrophic accidents through security warnings, and provide key information for planning maintenance. In addition, SHM also helps to verify the design assumptions and parameters for existing civil structures, as well as provides relevant information to improve the design specifications for future similar structures.

A typical SHM system generally consists of three major subsystems: a sensor subsystem, a data transmission subsystem, and a health evaluation subsystem. The structural responses are firstly measured by the sensor subsystem, then transmitted through the data transmission subsystem, and finally analyzed by the health evaluation subsystem. Therefore, the accuracy and reliability of health-condition evaluation results are largely dependent on the variety, quantity and quality of health-monitoring data measured by the sensor subsystem. In addition to acceleration responses, various advanced sensing technologies, such as fiber Bragg grating sensors [8, 9] and Global Positioning System receivers [10], have been developed recently to measure strain and displacement responses to increase the variety of health-monitoring data. The problem of optimal sensor placement has also attracted increasing attention from researchers in the SHM field. Solving this problem will enhance the ability of sensor subsystem to measure enough structural response information for health-condition evaluation with minimum number of sensors [11, 12]. The core functionality of SHM lies in providing timely health-condition evaluation and security warning for the monitored structure. A basic premise regarding these goals is that the health-monitoring data acquired from sensor subsystem has a good quality [13]. In other words, inaccurate evaluation results may be reflected by false alarms or missed detections if the health-monitoring data are distorted. As a result, false alarms may lead to economic losses due to unnecessary operational interruptions and structural maintenance. On the other hand, missed detections will increase the probability of catastrophic accidents. The dominant factor which causes distortions in health-monitoring data is the fault occurred in sensor subsystem. A sensor is commonly composed of different components, including sensing element, transducer, signal-processing module and communication interface. Any component may malfunction due to poor manufacturing, harsh service environments and normal performance degradation. This will lead to sensor faults to

*Correspondence to: Ting-Hua Yi, School of Civil Engineering, Dalian University of Technology, Dalian 116023, China.

†E-mail: yth@dlut.edu.cn