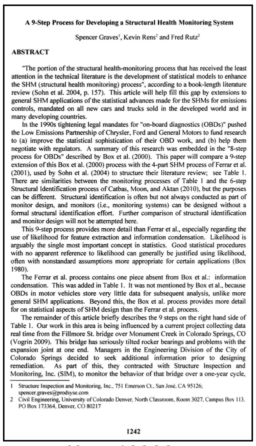

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A 9-Step Process for Developing a Structural Health Monitoring System

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"The portion of the structural health-monitoring process that has received the least attention in the technical literature is the development of statistical models to enhance the SHM (structural health monitoring) process", according to a book-length literature review (Sohn et al. 2004, p. 157). This article will help fill this gap by extensions to general SHM applications of the statistical advances made for the SHMs for emissions controls, mandated on all new cars and trucks sold in the developed world and in many developing countries.

In the 1990s tightening legal mandates for "on-board diagnostics (OBDs)" pushed the Low Emissions Partnership of Chrysler, Ford and General Motors to fund research to (a) improve the statistical sophistication of their OBD work, and (b) help them negotiate with regulators. A summary of this research was embedded in the "8-step process for OBDs" described by Box et al. (2000). This paper will compare a 9-step extension of this Box et al. (2000) process with the 4-part SHM process of Ferrar et al. (2001), used by Sohn et al. (2004) to structure their literature review; see Table 1. There are similarities between the monitoring processes of Table 1 and the 6-step Structural Identification process of Catbas, Moon, and Aktan (2010), but the purposes can be different. Structural identification is often but not always conducted as part of monitor design, and monitors (i.e., monitoring systems) can be designed without a formal structural identification effort. Further comparison of structural identification and monitor design will not be attempted here.

This 9-step process provides more detail than Ferrar et al., especially regarding the use of likelihood for feature extraction and information condensation. Likelihood is arguably the single most important concept in statistics. Good statistical procedures with no apparent reference to likelihood can generally be justified using likelihood, often with nonstandard assumptions more appropriate for certain applications (Box 1980).

The Ferrar et al. process contains one piece absent from Box et al.: information condensation. This was added in Table 1. It was not mentioned by Box et al., because OBDs in motor vehicles store very little data for subsequent analysis, unlike more general SHM applications. Beyond this, the Box et al. process provides more detail for on statistical aspects of SHM design than the Ferrar et al. process.

The remainder of this article briefly describes the 9 steps on the right hand side of Table 1. Our work in this area is being influenced by a current project collecting data real time from the Fillmore St. bridge over Monument Creek in Colorado Springs, CO (Vogrin 2009). This bridge has seriously tilted rocker bearings and problems with the expansion joint at one end. Managers in the Engineering Division of the City of Colorado Springs decided to seek additional information prior to designing remediation. As part of this, they contracted with Structure Inspection and Monitoring, Inc. (SIM), to monitor the behavior of that bridge over a one-year cycle, analyzing three types of data together: (a) Monthly surveys of northing, easting and elevation of 8 points on the bridge, (b) Monthly inclinometer readings from 20 meter deep test holes drilled in the street at each end of the bridge, (c) Real time monitoring of thermal cycling installed by SIM.

Ключевые слова:

Содержание.