ABSTRACT
The development of effective structural health monitoring (SHM) methodologies is imperative for the efficient maintenance of important structures in aerospace, mechanical and civil engineering. Based on reliable condition assessment, the owners of monitored structures can expect two important benefits: (1) to avoid catastrophic accidents by detecting various types of structural deterioration during operation, and (2) to establish efficient maintenance means and time schedule to reduce maintenance costs.

A vibration-based SHM methodology is evaluated for change detection in nonlinear systems that can be frequently seen in many engineering fields. The proposed methodology is advantageous over existing SHM methodologies regarding the following aspects: (1) it is feasible to detect small changes in complex nonlinear systems, (2) it is possible to make physical interpretation of detected changes, and (3) it is possible to quantify the uncertainty associated with the change detection.

A series of analytical and experimental studies was performed to investigate various important issues in modeling and monitoring of uncertain nonlinear systems. Different parametric and non-parametric identification methods were compared for monitoring purpose using full-scale nonlinear viscous dampers for seismic mitigation in civil structures. Then, the effects of uncertainty on change detection performance were investigated. Two types of uncertainty were studied: measurement uncertainty (or measurement noise) and system characteristic uncertainty (or variation of system parameters). For measurement uncertainty, three different types of full-scale nonlinear viscous dampers were used to validate the proposed SHM methodology when the dampers' response was polluted with random noise. For system characteristic uncertainty, a semi-active magneto-rheological damper whose system characteristics were determined through user controllable input current was used.

Statistical pattern recognition methods were studied to detect relatively small changes in nonlinear systems with different uncertainty types. The Bootstrap method, a statistical data resampling technique, was also studied to estimate the uncertainty bounds of change detection when the measurement data are insufficient for reliable statistical inference.

A web-based real-time bridge monitoring system was developed and used for a forensic study involving a cargo ship collision with the Vincent Thomas Bridge, a critical suspension bridge in the metropolitan Los Angeles region.

Keywords: structural health monitoring, system identification, Restoring Force Method, artificial neural networks, Hypothesis test, Bootstrap method, statistical pattern recognition, support vector machines, \textit{k}-mean clustering, error
analysis, detection theory, Natural Excitation Technique, Eigensystem Realization Algorithm, full-scale viscous dampers, magneto-rheological dampers, suspension bridge, web-based real-time bridge monitoring system, ship-bridge collision.

-------------------------------------------

Hae-Bum "ANDREW" Yun

Ph.D. Candidate and Graduate Research Assistant Department of Civil and Environmental Engineering University of Southern California 3620 S. Vermont Avenue Kaprielian Hall 268B Los Angeles, CA 90089-2531

office: (213) 740-6304
mobile: (310) 951-7575
fax: (213) 740-4526

email1: haebum@usc.edu
eemail2: haebum@hotmail.com