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DISSERTATION OUTLINE

Title: Phase Space Based Damage Detection for Bridge Vibration Monitoring

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Abstract:

Bridge evaluation methods based on vibration monitoring are increasingly used due to their convenience, but there is still limitation. Vibration-based damage detection methods in nowadays are not sensitive enough because some damages slightly affect on structural dynamic properties. In this study, phase space analysis, a method using information from several dimensions of vibration data, is expected to enhance the sensitivity of vibration-based damage detection method. The capability of phase space indices on detection of slight change of dynamic properties have been investigated both in numerical analysis and experimental works on an existing structural component. Due to the ability of phase space topology, a new phase space index has been proposed for detection of bridge support condition change and verified with artificial data, FE model, and field-experiment. Then, all phase space indices were applied with long-term vibration monitoring data and the “Characteristic Medical Chart” has been constructed for follow-up and check for a suspicious event. Examples were given by an earthquake event and field-experiment of bridge support condition change.

Dissertation outline

Chapter 1: Introduction

Chapter one contains the foundation information, including the importance of bridge monitoring system, limitation of using vibration responses, and advantages of phase space analysis are introduced. The literature review of each problem was investigated. And the purpose and objectives of the research are provided.

Chapter 2: Investigation of phase space indices for changes of dynamic properties

Phase space indices; Centroid Movement (CM), Smooth Orthogonal Coordinate (SOC), and Change of Phase Space Topology (CPST) have been investigated for detection of slight changes of dynamic properties; natural frequency and damping ratio. The investigation was done using a basic equation of motion for a single degree of freedom (SDOF).

Chapter 3: Experimental study on phase space indices on artificially damaged PC girders

The capability of phase space indices; CM, SOC, and CPST for damage detection due to slight changes of dynamic properties has been verified with experimental studies. The PC tendon damages represent severe hidden damage of a structure because the damages do not have much effect on vibration response, but at a certain level, the structure may suddenly collapse. However, phase space indices should detect such damages before it collapses.

Chapter 4: Proposal of a new phase space index for detection of high-frequency mode

A new phase space index is proposed using other features of phase space topology. The index mainly focuses on detecting the scattering due to the occurrence of a higher mode of frequency. An example of this situation is when bridge conditions change due to limited movement in a longitudinal direction, for example, the rust at bridge supports or gap closing due to temperature. The proposed index is verified with artificial data, FE model, and a field experiment on an actual bridge.

Chapter 5: Proposal of bridge condition evaluation method from acceleration monitoring data based on phase space indices

The bridge condition evaluation method is proposed based on all phase space indices. The “Characteristic Medical Chart” is constructed from long-term monitoring data and used for cross-checking with special events that are suspected of having damages. Examples of special events are earthquake records and field experiments in Chapter 4.

Chapter 6: Conclusions and recommendations for future work

Conclusions of this dissertation are stated, and future work is discussed.

The outline can be summarized as the following chart.

