We propose an approach to bridge structural monitoring that combines the advantages of a robust structural health monitoring paradigm with those of decentralizing the monitoring apparatus to fleets of vehicles that can continuously store or send data. The objective is to provide accurate, rapid, nearly continuous, and cost-effective assessments of several bridges. The new methodology envisions a set of moving vehicles equipped with sensors (which most of them already possess) able to capture the dynamic interaction between the vehicles and the bridge. As this interaction depends also on the modal characteristics of the bridge, we hypothesize that changes in the dynamic interaction can be inferred from damage-related features of the bridge. The methodology couples the sensing system to multi-resolution signal processing and pattern recognition algorithms to capture, locate, and classify variations in structural dynamic properties, e.g. resonant frequencies, mode shapes, or localized stiffness. The proposed approach can be considered as indirect (Figure 6), since it acquires information about the bridge from sensor-equipped vehicles moving over the bridge. This approach needs no installation of equipment on the bridge or any traffic control measurements, being highly distributed and mobile.

Desired Outcomes and Metrics

**Year 1:** (a) Progress report on the comparison of a variety of machine learning approaches using experimental data provided by the NSF project. (b) Comparison of the proposed multi-resolution algorithm and machine-learning approaches.  
**Year 2:** (a) Evaluation of automatic bridge feature detection. (b) Correlation of atmospheric conditions with dynamic vehicle-bridge interaction data.

Capabilities and Experience

**Lead:** Prof. Jim Garrett (CMU). He is Head of the Civil & Environment Department at CMU, and has developed several numerical vehicle-bridge interaction models to simulate bridge damage conditions, various vehicle types and different traffic flowing conditions. We have also modeled the vehicle-bridge interaction with 3D finite elements capable of capturing more realistic dynamic patterns. We are now moving this indirect monitoring approach to a new validation stage with data from two physical systems: a "bench-scale" vehicle-bridge system (with a motion control system for moving a scaled vehicle over a scaled bridge with both having attached accelerometers) and a full-scale real bridge under operation.

**J. Garrett, J. Bielak, J. Kovacevic, P. Rizzo**  
**Students:** F. Cerda, S. Chen, E. Romero

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