A Framework for Vehicle-bridge Interaction Simulation

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Vehicle-bridge Interaction (VBI)

Running vehicles create extra dynamic load to the bridge. This phenomenon is complex because they are coupled by their interaction through the contact forces, making the problem nonlinear and time-dependent.

History of VBI

Problem emerge: 170 years ago
1st theoretical study: 100 years ago
1st FEM implantation: 50 years ago
1st nonlinear analysis: 15 years ago

Current application

Structural design & construction
Structural health monitoring (SHM)
Drive-by detection
Bridge weight-in-motion

Future application: large-scale VBI systems

Intra-city transportation and logistics, truck platooning, autonomous vehicles, IoT-based SHM, extremely highspeed railway, …

VBI scales

Scale	Bridge length	No. vehicles	Key issues
Small	~ 100 m	~ 10	-
Medium	~ 1,000 m	~ 100	Asynchronous seismic excitation
Large	~ 10 km	~ 1,000	Curved deck & realistic traffic
Extra-large	~ 100 km	~ 10,000	Slope and bifurcation

Objective

Establish a framework for large-scale VBI system simulation.
Key points: nonlinearity, efficiency, and versatility.
Platform: a dozen scripts written in MATLAB.

Framework structure

Bridge module	Generate bridge structure matrices
Deck module	Provide an interface for VBI
Road module	Apply road roughness to the deck
Vehicle library	Unify vehicle model and parameters
Vehicle routing	Pre-defined or real-time routing strategy
Bandwidth reduction	Improve matrix operation efficiency
Seismic module	Asynchronous input for large systems
Nonlinearity	Material nonlinearity under earthquake

Simulation approach to establish interaction

Coupled, decoupled (tolerance/iteration control), and uncoupled.