A framework for Vehicle-bridge Interaction Simulation

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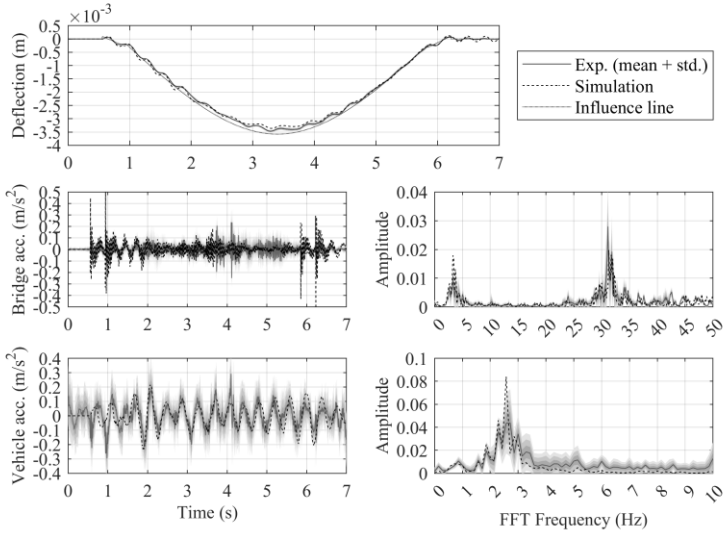
[Background] Vehicle-Bridge Interaction (VBI) studies the coupled motions of moving vehicles and bridges. It helps in bridge design and monitoring, as well as vehicle safety and comfort.
[Current issue] Generic finite element (FE) software lack modules designed for simple but time-varying systems like VBI, therefore they may limit the variety of VBI studies.
[Objective] This research proposed a versatile, realistic, accurate, and efficient framework for large-scale VBI system simulation. It consists of a dozen self-written functions in MATLAB.

[Key idea] A slope-and-curve deck can be mapped to flat-and-straight. Shape-induced effects can be replaced by external forces and moments.
[Methodology] The framework contains bridge, deck, and vehicle sections.
Bridge → Basic FEM, slope/curve support, asynchronous seismic excitation.
Deck profile → Roughness, contact (detachment), slope/curve support.
Vehicle library → An easy input format that unifies all road vehicles.
Vehicle driving behavior → car-following model for various traffic scenarios.
[Algorithm] Coupling is established by contact forces through iterations.
The decoupled approach with matrix decomposition is used for efficiency.
The HHT-alpha method is used for direct integration of structural response.
[Innovation] The idea of the vehicle library and the general vehicle input.
All road vehicles can be divided into 1) units, 2) axle sets, and 3) wheels.
1 & 2 together generate vehicle matrices, and 3 controls the V/B contact.

[Verification] The framework is verified with a lab exp. and a ref. paper. The results agree well, indicating the framework is accurate and efficient in VBI simulation, and is reliable in seismic analysis.



EQ	Term	Ref. paper	Framework	Error
GI-0	Peak acc (Gal)	164	163	0.6%
	RMS acc (Gal)	33.9	42.5	25.5%
	FFT peak (Hz)	1.51	1.48	-2.0%
GII-0	Peak acc (Gal)	236	226	-4.2%
	RMS acc (Gal)	77.7	80.7	3.9%
	FFT peak (Hz)	1.64	1.63	-0.4%

[Future development] The framework needs improvement on nonlinearity, plate/bar elements, and large VBI system verification.