Modelling, Identification and Active Vibration Control of a Lightweight Stress Ribbon Footbridge

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Abstract

The presentation reviews a recently published active vibration control scheme for a footbridge based on grey-box model identification to reduce pedestrian-induced vibrations [1]. A Carbon Fibre Reinforced Plastic (CFRP) stress ribbon bridge with a span of 13 m has been built at the Technische Universität Berlin. Its lightness and flexibility result in high vibration sensitivity. The feasibility of the new control approach was demonstrated in simulations using an experimentally validated linear state-space model of the real footbridge. The active forces to control the first three vertical modes are generated by three pairs of pneumatic muscle actuators (PMA) that are installed in the footbridge's handrail. The motion of the bridge is sensed by two accelerometers placed below the bridge deck. To design the control system, a linear grey-box state-space model was determined with the reference forces of the exact I/O-linearization controlled PMAs as inputs and the two vertical accelerations as outputs. Based on the identified model, an observer estimates the vertical modal velocities. After statically decoupling the first three modes by an input transformation, each of these modes can be controlled by a delayed velocity feedback to bring modal velocity and control force in phase. Gain and delay of the controllers have been chosen by means of the root locus method.

Literature

[1] Schauer, T., Liu, X., Jirasek, R. & Bleicher, A. Acceleration-based active vibration control of a footbridge using grey-box model identification. *IEEE International Conference on Advanced Intelligent Mechatronics (AIM)* 910-915 (2017).