Physics-informed sparse identification of a bistable nonlinear energy sink

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Abstract. Bistable nonlinear energy sinks have attracted extensive attention due to their efficient broad-band targeted energy transfer over a wide range of input energy levels. The precise identification of local bistability is of significance to predicting and enhancing the system performance of the vibration energy absorption. However, a multi-degree-of-freedom system with local bistability is difficult to be measured and identified because of snap-through motions. Moreover, the basis functions of many current data-driven identification methods lack physical interpretability. This paper proposed a physics-informed sparse identification method for parameter estimation of bistable nonlinear energy sinks. The restoring force surface is constructed on the local bistable structure and the nonlinear restoring force trajectory is intercepted by assuming two quasi-zero velocity planes. Furthermore, the candidate functions can be physically informed in a sparse identification algorithm by conducting the least-square parameter fitting of the intercepted nonlinear restoring force trajectories.

Introduction

Over the past two decades, passive nonlinear energy sink has been a subject of growing interest due to its wide applications in the fields of vibration mitigation and energy harvesting. Among various nonlinear energy sink devices, it seems that bistable configurations may allow for efficient broad-band targeted energy transfer over a wide range of input energy levels. However, introducing bistability brings a great challenge for nonlinear restoring force identification in practical applications due to the snap-through characteristics in static deformation and cross-well motions in dynamic responses. The traditional restoring force surface method and Hilbert transform-based method may have insufficient accuracy due to noise disturbance. Besides, modern machine learning methods lack physical interpretability in the selection of basis functions.

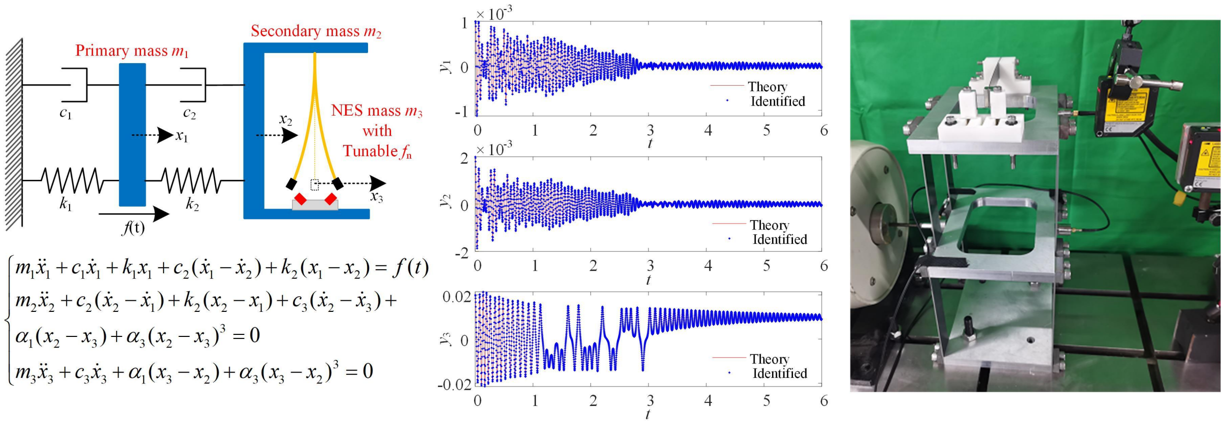

Figure 1: Modeling, Identification and Experimental Validation of A Bistable Nonlinear Energy Sink.

Results and Discussion

This study proposes a physics-informed sparse identification method for the accurate identification of bistable nonlinear energy sinks. The restoring force surface is constructed on a bistable nonlinear energy sink equation and the nonlinear restoring force trajectory is intercepted by assuming two quasi-zero velocity planes. Furthermore, the sparse regression algorithm is conducted based on physics-informed candidate functions and the free vibration response of bistable nonlinear energy sink systems. Numerical simulations are conducted on a three-degree-of-freedom bistable nonlinear energy sink. The results show that the proposed method not only gives sparse identification physics information but also improves the accuracy by 2.64% under the noise level of 30dB. Experimental verifications are performed on a three-story beam-type bistable energy sink structure. Compared to two traditional nonparametric methods: Hilbert transform-based method and restoring force surface method, the superiority has been demonstrated.

References

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