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Title: Influence of noise on First Passage Time maps and their use for early damage detection

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Abstract

In structural health monitoring, First Passage Time (FPT) is defined as the random time spent by a stochastic system to evolve from an initial to a terminal energy level. By pairing various values of the initial and terminal energy levels, statistics of the FPT (such as average or standard deviation) can be represented in so-called FPT maps. Besides, histograms of the FPT for some specific combinations of initial and terminal energy levels provide additional information about the system dynamics. This way to process time series collected on real structures under unmeasured environmental loading has been made possible thanks to the development of efficient algorithms.

Previous works have revealed that FPT maps and histograms have a great potential to detect slight damage [1,2]. In-lab demonstrators on a steel strip have been used as prototypes to develop a proof-of-concept. However, in real-life applications, the level of ambient noise might be higher than what has been considered in the lab experiments. Also, the type of noise (white, brown, pink, band-limited or non, etc.) is expected to make the detection procedure more difficult. It is indeed known that the effect of noise can complicate damage detection, especially when the input is unknown and under changing environmental conditions [3].

In order to evaluate the sensitivity of the damage detection technique based on FPT maps and histograms to noise, an exhaustive study has been carried out. It is based on numerical simulations of a simple LTI system mimicking the experimental setup of the steel strip previously used by the authors. On one hand, this system has been subjected to unmeasured noises of various types as exogenous loading. On the other hand, the measured output has been also corrupted by various types of noise, pretending that the measurement was imperfect. The influence of several combinations of such modifications of the input and output of the model has been studied carefully. The proposed exposé will deliver the major outcomes of this study in terms of statistical descriptions and fault detectability conditions.

References

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