Multiobjective optimization for identification of a moving load path

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ABSTRACT

This contribution is devoted to the problem of indirect identification of a moving load based on the measured mechanical responses of the loaded structure. In general, this is an inverse problem, which has been intensively studied, and with a number of published reviews [1–3]. Such problems are typically characterized by (1) a very large number of the structural degrees of freedom that can be excited by the moving load and (2) a limited number of sensors that are used to measure the response. In effect, the naïve formulation based on minimization of the norm of the response residuum is underdetermined, and the corresponding identification problem has an infinite number of exact solutions. Therefore, in order to guarantee the uniqueness of the solution, it is typical to limit the generality of the load by assuming that the trajectory of the moving load is known (most often, the problem is reduced to the case of a single vehicle moving over a 1D bridge at a constant velocity) and that only the magnitude of the load is a subject to identification.

In contrast, our aim is to identify more general loads, and in particular loads that are freely moving on 1D structures like beams and on 2D structures like plates. In an earlier approach [4], we have used the sparsity-based optimization, constrained using the $l1$ norm, which guarantees the uniqueness of the solution. It has been found that it is possible to reliably identify the trajectory of the load moving on a 1D structure (beam), including its timing (decelerations, stops, accelerations, etc.).

In this contribution, the aim is to qualitatively identify the trajectory of a moving load that excites a 2D structure. To limit the generality of the search space, we notice that 2D trajectories of such loads are continuous and relatively smooth. Therefore, in analogy to the object tracking approaches developed in the computer vision community [5], we use an assumption of smoothness in a multicriterial-type optimization, which weights the norm of the measurement residuum vs. a certain spline-based measure of the smoothness of the trajectory. In experimental investigations, we have used an approx. 1 m x 1 m plate, loaded by a line follower robot, and instrumented with a limited number of strain gauges.

REFERENCES

[1] X.Q. Zhu and S.S. Law, “Recent developments in inverse problems of vehicle–bridge interaction dynamics”, *Journal of Civil Structural Health Monitoring*, Vol. **6**, No. 1, pp. 107–128, (2016).

[2] L. Yu and T.H.T. Chan, “Recent research on identification of moving loads on bridges”, Journal of Sound and Vibration, Vol. **305**, No. 1–2, pp. 3–21, (2007).

[3] M. Klinkov and C.P. Fritzen, “An updated comparison of the force reconstruction methods", *Key Engineering Materials*, Vol. **347**, pp. 461–466, (2007).

[4] M. Gawlicki and Ł. Jankowski, “Identification of moving loads using the l1 norm minimization”, *AIP Conference Proceedings*, Vol. **1922**, art. id. 100007, (2018).

[5] A. Milan, K. Schindler and S. Roth, “Multi-target tracking by discrete-continuous energy minimization”, *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol. **38**, No. 10, pp. 2054–2068, (2016).