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IDENTIFICATION OF A MOVING LOAD 2D PATH UNDER INSUFFICIENT INSTRUMENTATION

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1 INTRODUCTION

This contribution is devoted to the problem of indirect identification of 2D trajectories of moving loads based on the measured mechanical responses of the loaded structure. This is an inverse problem of load identification, and such problems have been intensively studied [1,2]. Such problems are typically characterized by (1) a very large number of 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 residuum norm is underdetermined, and the corresponding identification problem has an infinite number of exact solutions. Thus, in order to guarantee the uniqueness of the solution, the generality of the load is typically limited 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 subject to identification. In contrast, our aim here is to identify more general loads, and in particular trajectories of loads that are freely moving on 2D structures like plates.

2 LOAD PATH IDENTIFICATION

In an earlier approach [3], we have identified paths of single and multiple loads moving on 1D structures (beams) by using the assumption of load sparsity (in time and space). It has been found that it is possible to identify the path of the load, including its timing (decelerations, stops, accelerations, etc.).

Here, we focus on 2D structures and 2D load trajectories, and report on two approaches to provide for the missing measurement information: (1) by sparsity-based optimization, in which the search space is constrained by using the l_1 norm and load nonnegativity, and (2) by noticing that 2D load trajectories can be expected to be 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. The approaches are verified experimentally using an approx. 1 m $\times$ 1 m steel plate, loaded by a line follower robot, and instrumented with a limited number of strain gauges, see Fig. 1. Preliminary results obtained using the second approach are illustrated in Fig. 2.

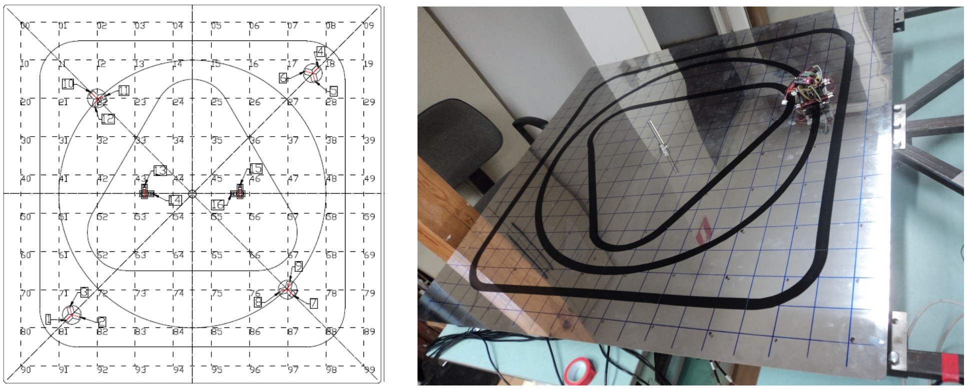

Figure 1: Experimental stand: (left) schema of the plate with load rasterization points, sensors and typical trajectories marked; (right) a photo of the plate loaded by the line follower robot.

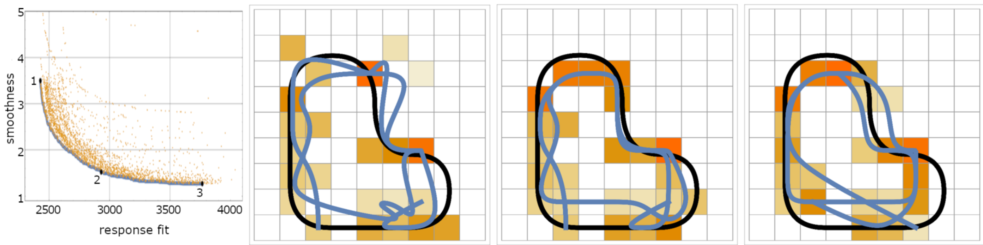

Figure 2: Multiobjective identification of a 2D trajectory, a preliminary example. The leftmost plot is the Pareto front of trajectory smoothness vs. response fit. The three points on the front correspond to the trajectories shown in the subsequent plots, where the actual and identified trajectories are shown respectively in black and blue (top view), while the rasterization shows the loading points and identified (time-aggregated) force values.

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