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HIGH-FIDELITY DIGITAL TWINS: DETECTING AND LOCALIZING WEAKNESSES IN STRUCTURES

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Abstract. Given that all materials exposed to the environment and/or undergoing loads eventually age and fail, the task of trying to detect and localize weaknesses in structures is common to many fields. To mention just a few: bridges, high-rise buildings, stadiums, airplanes, drones and missiles, turbines, launch pads and airport infrastructure, wind turbines, and satellites. Traditionally, manual inspection was the only way of carrying out this task, aided by ultrasound, X-ray, or vibration analysis techniques. The advent of accurate, abundant and cheap sensors, together with detailed, high-fidelity computational models in an environment of digital twins has opened the possibility of enhancing and automating the detection and localization of weaknesses in structures. The procedures proposed here are based on measured forces and displacements/strains, and formulate the determination of material properties (or weaknesses) as an optimization problem for the strength factor. These procedures belong to the more general class of inverse problems where structural properties are sought based on a desired cost functional. The use of adjoint formulations and smoothing of gradients to quickly localize damaged regions makes the problem tractable. In a subsequent step, techniques to minimize the number of load cases and sensors are proposed and tested. Several examples show the viability, accuracy and efficiency of the proposed methodology and its potential use for high fidelity digital twins.