From nonlinear system identification to structural health monitoring

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The process of implementing a damage monitoring strategy for aerospace, civil and mechanical engineering infrastructure is referred to as structural health monitoring (SHM) and implies a sensor network that monitors the behavior of the structure on-line. A SHM process potentially allows for an optimal use of the monitored structure, a minimized downtime, and the avoidance of catastrophic failures. The SHM process classically relies on four sequential steps that are damage detection, localization, classification, and quantification. The key idea underlying this seminary is that structural damages may result in nonlinear dynamical signatures that are not yet used in SHM despite the fact that they can significantly enhance their monitoring. We thus propose to monitor these structural damages by identifying their nonlinear signature on the basis of a cascade of Hammerstein models representation of the structure. This model is here estimated at very low computational cost by means of the Exponential Sine Sweep Method. It will be shown that on the basis of this richer dynamical representation of the structure, SHM algorithms dedicated to damage detection, classification and quantification can be derived. This will be illustrated in the aeronautic and civil engineering contexts and using experimental as well as numerical data.