Editorial for the Special Issue on Novel Approaches for Structural Health Monitoring II

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The emphasis of this Special Issue is on showcasing the most recent advancements in the field of Structural Health Monitoring (SHM), accounting for all its applications in mechanical systems and civil structures or infrastructures. The eight papers presented here represent relevant contributions in their specific aspects.

In the work of Concli, Pierri and Sbarufatti [1], transmission maintenance for the condition monitoring of gearboxes was addressed. Specifically, the researchers considered a back-to-back test rig consisting of two parallel axes gearboxes connected by means of two shafts in a closed mechanical loop. They also focused on surface damage (namely, pitting), numerically simulating several types and severities of damage. The proposed Machine Learning (ML) approach, based on a multilayer perceptron, is able to perform damage detection, localization and quantification. The training phase of the Artificial Neural Network (ANN) was performed resorting to signal examples generated by a hybrid analytical–numerical model.

Janardhan Padiyar et al. [2] presented a synergistic non-destructive method for the automated inspections of aircraft composite structures. Specifically, a sensor fusion procedure was outlined, combining two image-based non-destructive evaluation (NDE) techniques: phased-array ultrasonic testing and infrared thermography. The approach was experimentally validated on an aircraft-grade painted composite material skin panel with stringers. Importantly, the miniaturized sensor systems tested and validated here were intended to be integrated in a vortex-robotic platform inspector, in the framework of the Horizon-2020 'CompInnova' project.

The work of Lin and Wu [3] concerned the well-known Stochastic Subspace Identification (SSI) technique, widely used for the output-only system identification of a target structure or mechanical system from ambient vibration testing. This falls into the field of Operational Modal Analysis (OMA). Importantly, two main variants of the SSI algorithm exist: the covariance-driven SSI (SSI-COV) and the data-driven SSI (SSI-DATA). In brief, the second option (SSI-DATA) operates directly on measured output response data with no further processing. Conversely, SSI-COV utilizes the covariance functions for the purpose of modal parameter estimation; these need to be estimated in advance from raw output time histories. In this context, the authors introduced a procedure to solve the system matrix in SSI-COV in conjunction with SSI-DATA, allowing modal estimation to be well implemented.

Civera and Surace [4] discussed an application of Instantaneous Spectral Entropy (ISE) for the real-time condition monitoring of a faulty three-stage gearbox. In particular, the case study came from a 2.5 MW Nordex N100 wind turbine located in Northern Sweden. The proposed algorithm employs the instantaneous formulation of Shannon Spectral Entropy (SSE), which was proven to be damage-sensitive in previous studies on masonry buildings and steel pipelines, in combination with Continuous Wavelet Transform (CWT). The Generalized Morse Wavelet (GMW) was proposed as the best choice for the CWT mother wavelet. A sensitivity analysis was performed on the two GMW parameters

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(symmetry γ and compactness β), suggesting the use of $3 \leq \gamma \leq 4$ and $20 \leq \beta \leq 40$ to increase fault detectability.

The work of Delo et al. [5] explored a remote sensing approach to SHM, based on interferometric data and focusing on representation techniques that can be adopted to highlight their advantages for the field. In the paper, the authors analyzed Line-of-Sight displacement records from the urban area of Rome (Italy). They analyzed an area subject to the construction of a new subway line. These data were exploited to create a velocity map to highlight the possible subsidence phenomenon induced by excavations. Then, entropy–energy representations were applied to single buildings and building complexes. Finally, the authors concluded that future developments and the continuous increase in the quality of satellite data may allow for the practical application of such information for SHM, leading to a low-cost automated process for the study of large urban areas.

Ceravolo et al. [6] proposed a methodology to approach the identification of interconnected diaphragmatic structures using a simplified analytical model (i.e., spring–masses model). The simplified model is exploited to aid the identification of a significant case study, represented by the Pavilion V, designed by Riccardo Morandi as a hypogeum hall in the Turin Exhibition Center composed of three interconnected blocks with joints. Not only does the presence of these joints result in modal complexity but also in very high sensitivity of the stiffness parameters, especially when the joints are fully effective. This complexity also affects the design of the experimental setups, which are often unable to capture the whole-body dynamics. As the main result, light was shed on the contribution of the stiffness of the joints to the global dynamic behavior of structures composed of interacting diaphragms and, in particular, on the effectiveness of the joints of Pavilion V.

Tufisi et al. [7] evaluated the damage severity of cantilever beams by means of an optimization algorithm known as Stochastic Hill Climbing (SHC). This is applied to the deflections of fixed-free structural elements with both open and closed cracks at different locations. The algorithm, which was implemented in a Python application named PySHC, was validated via an experimental test. It was found to be capable of estimating the location and depth of the crack with minimal error (respectively, 1.1% and 0.3 mm).

Tola et al. [8] presented a critical review of bridge monitoring methods and ML algorithms for scour detection. This is an extremely relevant topic, as foundation scour is one of the first causes of total or partial bridge collapse. Furthermore, its effects are mainly located underwater and are, thus, not detectable from visual inspection only. They also depend on underground soil conditions that are even more difficult to investigate from above ground. The authors present and detail the techniques and the main outcomes of 36 studies, divided into two broad categories: conventional-monitoring-based studies and advanced Machine-Learning-based studies to detect scour.

In conclusion, this Special Issue collected high-quality contributions on various SHM applications in applied sciences, and it also provided a solid state-of-the-art reference in this research area.

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References

1. Concli, F.; Pierri, L.; Sbarufatti, C. A Model-Based SHM Strategy for Gears—Development of a Hybrid FEM-Analytical Approach to Investigate the Effects of Surface Fatigue on the Vibrational Spectra of a Back-to-Back Test Rig. *Appl. Sci.* **2021**, *11*, 2026. [CrossRef]
2. Janardhan Padiyar, M.; Fragonara, L.Z.; Petrunin, I.; Raposo, J.; Tsourdos, A.; Gray, I.; Farmaki, S.; Exarchos, D.; Matikas, T.E.; Dassios, K.G. Fast, Accurate, and Reliable Detection of Damage in Aircraft Composites by Advanced Synergistic Infrared Thermography and Phased Array Techniques. *Appl. Sci.* **2021**, *11*, 2778. [CrossRef]
3. Lin, C.S.; Wu, Y.X. Response-Only Parametric Estimation of Structural Systems Using a Modified Stochastic Subspace Identification Technique. *Appl. Sci.* **2021**, *11*, 11751. [CrossRef]

4. Civera, M.; Surace, C. An Application of Instantaneous Spectral Entropy for the Condition Monitoring of Wind Turbines. *Appl. Sci.* **2022**, *12*, 1059. [CrossRef]
5. Delo, G.; Civera, M.; Lenticchia, E.; Miraglia, G.; Surace, C.; Ceravolo, R. Interferometric Satellite Data in Structural Health Monitoring: An Application to the Effects of the Construction of a Subway Line in the Urban Area of Rome. *Appl. Sci.* **2022**, *12*, 1658. [CrossRef]
6. Ceravolo, R.; Lenticchia, E.; Miraglia, G.; Oliva, V.; Scussolini, L. Modal Identification of Structures with Interacting Diaphragms. *Appl. Sci.* **2022**, *12*, 4030. [CrossRef]
7. Tufisi, C.; Rusu, C.V.; Gillich, N.; Pop, M.V.; Hamat, C.O.; Sacarea, C.; Gillich, G.R. Determining the Severity of Open and Closed Cracks Using the Strain Energy Loss and the Hill-Climbing Method. *Appl. Sci.* **2022**, *12*, 7231. [CrossRef]
8. Tola, S.; Tinoco, J.; Matos, J.C.; Obrien, E. Scour Detection with Monitoring Methods and Machine Learning Algorithms—A Critical Review. *Appl. Sci.* **2023**, *13*, 1661. [CrossRef]