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Editorial: Structural sensing for asset management

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Editorial on the Research Topic
Structural sensing for asset management

Managing existing civil infrastructure is challenging due to evolving functional requirements, material aging, climate change, and code adjustments, which reflect aspects such as loading modifications. With economic, environmental, and material resources becoming increasingly scarce, more sustainable solutions for practical asset management are required. Conservative approaches and assumptions in construction design and practice often result in a hidden reserve structural capacity of infrastructure assets. Interpreting monitoring data has the potential to unlock this untapped capacity, thus improving decision-making without putting users at risk. For example, better knowledge of the structural performance through monitoring may be leveraged to extend service durations, optimize structural rehabilitation, focus inspection, and prioritize maintenance activities. In addition, structural sensing allows the detection of onset of damage and diagnosis of the consequences on structural capacity, thus enabling the safe functionality of built assets.

This Research Topic focuses on data interpretation methods for infrastructure management. Contributors were invited to propose novel strategies to use field measurements of existing structures for an informed decision-making at both the infrastructure and network scales, thus enabling better asset management. Four manuscripts have been successfully accepted for the Research Topic. These papers provide contributions on several structural monitoring aspects for more sustainable and safe infrastructure management.

Data interpretation is a crucial step in the implementation of structural sensing frameworks. Pai et al. provide methodology maps of the various data interpretation methodologies available to support asset management. Given the uncertainty levels and the magnitude of bias, one of the three investigated methodologies (residual minimization, Bayesian model updating, and error-domain model falsification) is recommended on the basis of nineteen full-scale case studies. These case studies also show that robust model-based data interpretation supports the quantification of reserve capacity that is often present in built infrastructure due to conservative design and construction practices. Moreover, an open-source software has been developed to support data interpretation, subsequent validation, and what-if analyses.

Bertola et al. provide a perspective on the usefulness of structural monitoring for bridge examination. The authors first highlight the difference between structural performance monitoring (the identification of structural properties) and structural health monitoring (the permanent and automated process of identifying and diagnosing damage). Then, the information gain of four monitoring techniques (load testing, continuous monitoring, weigh-in-motion, and non-destructive tests) is evaluated on a full-scale bridge case study from Switzerland. The monitoring results show that each monitoring technique provides unique information. The maximum information gain is reached by combining all the available techniques. Bridge safety evaluations are significantly influenced by monitoring data and leveraging the monitoring information, and decision-making based on the bridge safety could even be changed, avoiding unnecessary structural maintenance and paving the path towards better asset management.

Mukai et al. present dynamic measurements collected during seismic micro-tremors from unreinforced masonry buildings after the damaging 2015 Gorkha (Nepal) earthquake. After visually attributing damage tags to a city district, vibration measurements are conducted by the authors for a subset of 11 buildings to obtain the fundamental frequency in the two main directions of the buildings. The damage state of the building is encoded as the ratio between the measured frequencies and its simulated counterpart, which is obtained using simplified models that encode the rough geometry of the buildings. Such rapid data-driven tools for building evaluation may form a crucial contribution to post-earthquake asset assessment management.

Luleci et al. address the challenge of the scarcity of real-world data of healthy and—even more limited—damaged civil engineering structures, which hinders the application of many machine learning applications to structural health monitoring. The use of a generative adversarial network, inspired by computer vision applications, helps to overcome missing data or unbalanced datasets that undermine the successful application of non-parametric damage diagnosis. Raw vibration data, generated from limited recorded data, are successfully used for damage diagnostics with a deep convolutional neural network on a steel laboratory frame. A data generator is an essential step towards the use of deep learning models in civil engineering SHM applications.

Despite the difficulties in accounting for large uncertainties in the monitoring and assessment of infrastructure, the cutting-edge research presented in this Research Topic clearly demonstrates through real-world case studies that data-informed infrastructure management is possible in a near future.

Author contributions

NB, YR, and EB contributed to the conception, writing, and proofreading of this editorial.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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