Editorial

Introduction

Structural health monitoring (SHM) is a wide area of engineering that focuses on the verification of the state or health of structures in order to ensure proper performance using nondestructive tests, involving sensors permanently attached to the structure, how these sensors are distributed and computational algorithms. When a structure needs to be inspected, a SHM system is able to improve the quality of the analysis adding several advantages or benefits. Among these advantages are knowledge about the structural behavior under different loads and different environmental changes, as well as knowledge on the current state in order to verify the integrity of the structure and determine whether a structure is able to perform properly or whether it needs maintenance or replacing (with the corresponding maintenance cost saving). In the same way, condition monitoring is a related area that allows the application of algorithms to evaluate and monitor parameters in machinery which are working together with the structures. Both research areas consider the use of sensors installed in the system to monitor and develop data-driven and data fusion algorithms to evaluate the condition of the structures and the machinery.

General discussion

This special collection features eight selected high-quality papers which address different condition monitoring and SHM applications based on the use of sensors and data-driven algorithms. Following are a brief description of each work.

Xu and Yang\(^1\) investigate the deformation behavior of an arched structure using a new method to obtain the displacement information as well as the displacement direction efficiently. The displacement information is extracted using a three-dimensional terrestrial laser scanning (TLS). One of the main outcomes of this work is related to the fact that the transverse displacement plays a fundamental role in the safety of the structure. This contribution points out that it is not sufficient to assess the current state of a structure based on vertical displacements, as in the surface approximation method. Therefore, the combination of both a panorama- and surface-based SHM strategies is required to ensure the safety of complex structures.

Wang et al.\(^2\) proposed an individual cylinder air–fuel ratio estimation algorithm for a gas fuel engine with asymmetrical exhaust runners. The proposed algorithm is based on Kalman filtering where the coefficient matrix update step is added to the iterative process of common Kalman observer. As a result, the modified Kalman observer is able to estimate the individual cylinder air–fuel ratio with a maximum error less than or equal to 1% under steady-state conditions. As a consequence, with the proposed approach, the gas fuel injection devices can compensate for their mass flow rate differences. When some white noise is added to the measures of the sensors, the steady-state estimation results are almost the same, except that there are small fluctuations at the transition point.

Qi et al.\(^3\) proposed a simple and adaptive activity recognition method based on the molecular attribute. The authors are able to accurately classify six human activities, including walking, jogging, running, going upstairs, going downstairs, and sitting down. In the approach, the measured acceleration is considered as the material flow with a certain molecular structure. Similarly, the statistical and structural features are extracted using the molecular attributes. The final classification is based on a reliability-based voting. The proposed strategy, with an average recognition rate over 97%, improves previous approaches based on Bayesian networks, decision or naive Bayesian trees, or support vector machines.

Ramírez López et al.\(^4\) investigate an Internet-of-things system for healthcare to control medical variables according to recent breakthroughs in sensors and data processing. One of the contributions of this work is the reduction in energy consumption with the optimization of data acquisition integrated into a secure architecture. More precisely, the proposed system uses the oxygen saturation in the blood as well as the heart rate per minute as the main medical parameters. The
experimental results were statistically treated for a difference in population means to prove the accuracy of the model.

Leon-Medina et al. propose a data-driven methodology for the classification of liquids using an electronic tongue. The electronic tongue uses multi-frequency large amplitude pulse signal voltammetry. This work clearly shows that data integration, data reduction, and data transformation are of paramount importance. More precisely, it uses a three-dimensional unfolding for data integration and principal component analysis for both data reduction and data transformation. This study includes the comparison of several machine learning approaches that includes k-nearest neighbor, linear discriminant analysis classification trees, naive Bayes, random forest, and support vector machines. Fine k-nearest neighbor is the approach with the best performance.

Cañete et al. show the design and construction of a monitoring system for slab track systems that measure vibrations and displacements in the track of high-speed railway infrastructures. The system is evaluated by using measures of vibration and displacement in the track. These data are acquired and sent to passing trains, which are in charge of transporting the information to a remote server. Data are saved in a database and are used for damage detection by evaluating changes in the modal parameters. Results show the advantages of the developed system and give directions and recommendations for its implementation as well as some lesson learned in the development of the system.

Xu et al. highlight the little attention paid in the developments about the performance for multi-direction strain monitoring of the carbon nanotube film sensor and proposes a strain monitoring with this sensor taking advantage of the characteristics for multi-direction strain measurement. As part of the evaluation of these characteristics, circular and rectangular carbon nanotubes sensors are used. Tests include these sensors bonded to the surface of some composite structures to perform stretching tests with and universal tensile machine to compare and evaluate these sensors and highlighting the advantages of circular carbon nanotubes for SHM of composite structures.

Zhang et al. investigate the combination of some algorithms for wheel-set size prediction to provide a solution to the inspection of wheels in high-speed trains as a methodology for fault detection and an alternative to increase the safety in the operation of this kind of trains. These algorithms are used to propose a methodology called adaptive differential evolution algorithm Levenberg–Marquardt back propagation wheel-set size prediction model which is evaluated with data from a LY series dynamic inspection system installed on an operation line. Results show the advantages in the use of the methodology and the opportunities for its use as a safety monitoring system.

References

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