Vibration data and underlying physics for adaptive structural health monitoring

In the context of long-term monitoring applications, there are numerous structural states that exhibit similar behavior but cannot be generalized with a single model (whether data- or physics-based) due to the inherent time-variant nature of structural evolution (1). Addressing such scenarios necessitates methodologies with adaptable models that can capture the interdependencies between Environmental and Operational Variabilities (EOV) and Damage Sensitivity Features (DSF) at various stages of structural evolution. The challenge lies in determining when distinct structures can be considered pseudo-similar, thereby sharing the same underlying physical properties to better represent the dynamics and associated EOV dependencies. Similarly, the incorporation of physics-based models, with varying levels of fidelity, adds knowledge towards understanding structural changes, which is essential for incorporating interpretable constraints on DSF evolution.

In practice, there are two main Challenges: (i) Robust extraction of DSF for continuous monitoring which are insensitive to EOVs. These DSF should be interpretable during the entire evolution of the structural performance and they should be able to accommodate dimensionality and complexity reduction of their associated non-linear time-variant nature. (ii) And there is a need of developing measures to quantify and propagate uncertainty towards the estimation of future stages of the structure evolution.

Interests on: Structural mechanics and dynamics, Stochastic modelling and Uncertainty quantification.
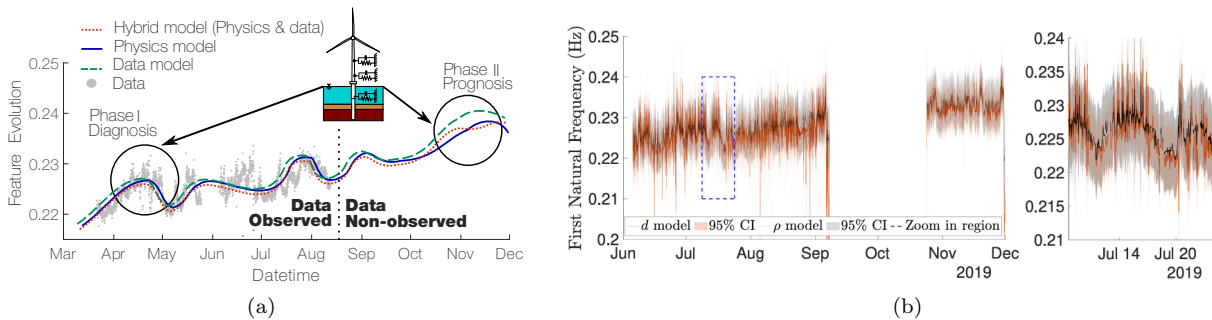

Figure 1: (a) Illustration of feature evolution over time with data and underlying physics and (b) Evolution natural frequencies with multiple phases EOV and DSF model (2)

References:

(1) García Cava D., Avedaño Valencia L. D., Movsessian A., Roberts C. and Tcherniak D., On explicit and implicit procedures to mitigate environmental and operational variabilities in data-driven structural health monitoring. Chapter in the Book on Structural Health Monitoring Based on Data Science Techniques. Structural Integrity, Springer, pp. 309-330, vol 21, Cury A., Ribeiro D., Ubertini F., Todd M.D. (eds). 2021 (DOI: doi.org/10.1007/978 − 3 − 030 − 81716 − 9_15)

(2) Qu, K., Logan, A., Miller, M. and García Cava D., Multi-phase adaptive methodology for mitigating environmental and operational variability in slowly changing time-variant engineering structures. *Mechanical Systems and Signal Processing*, 229:112494 , 2025. (DOI: doi.org/10.1016/j.ymssp.2025.112494)

Requirements: Minimum entry qualification - an Honours degree at 2:1 or above (or international equivalent) in a relevant science or engineering discipline, possibly supported by an MSc Degree. Applications are particularly welcome from candidates expecting to receive a first-class degree in mechanical engineering, physics, applied mathematics or a closely related subject.

Funding: Applications are welcomed from students who are applying for scholarships from the University of Edinburgh or elsewhere as well as self-funded students.

*Competition (EPSRC) funding may be available for an exceptional candidate but please note you must be a UK student or an EU student who has lived in the UK 3+ years.