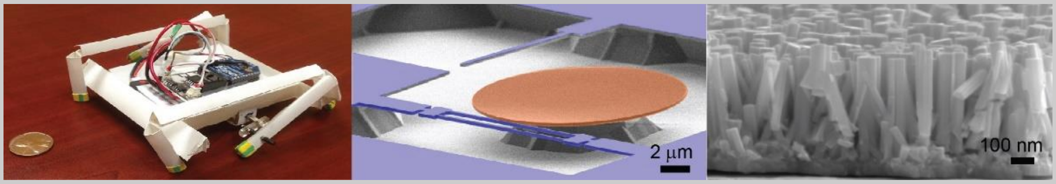
WPI MECHANICAL ENGINEERING



Digital Twin for Dynamic Characteristics and Prognostics via Deep Learning and Advanced Sensing

Dr. Zhu Mao
Department of Mechanical Engineering
University of Massachusetts, Lowell

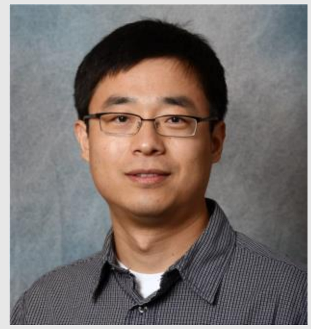
12:00pm -1:00 pm, Friday, May 14th
Zoom Link: https://wpi.zoom.us/j/97396532445

A digital twin is a reduced-order representation of a sophisticated real-world system or process, which leverages known physics and real-time data for the ultimate goal of status awareness, design enhancement, manufacturing optimization, condition-based maintenance and retrofit, operational risk minimization, etc. Yet any such metamodeling effort is inevitably constrained by the lack of high-fidelity physics knowledge, and corrupted by the poor observability of the sensing hardware and various kinds of uncertainties.

As the primary functionality of digital twins, research on accurate estimation of the system dynamics and prediction of its deterioration will be focused in the first half of this presentation. Specifically, deep neural network (convolutional long short-term memory) will be introduced to characterize the operation conditions of rotating machineries, and predict the remaining useful life. To obtain a better quality of the prediction and interpretability of deep learning models, physics is also involved through adaptive filtering to regulate the estimations. Run-to-failure tests on bearings are conducted to validate the algorithm.

The second half the presentation concerns noncontact sensing using video cameras, which is a fundamental departure from traditional measurement using instrumented physical sensors and drastically improve the potential of digital twins. In particular, phase-based motion extraction and amplification is adopted to recognize system status and complex structure dynamics. Modal identification is implemented on wind turbine blades, and subtle invisible dynamics is successfully extracted with full-field information maintained. Probabilistic uncertainty quantification model will also be introduced in the end, which intrinsically enhances the capability of digital twins in detecting system changes with statistical significance.

About the Speaker



Zhu Mao received his B.S. from Tsinghua University in 2002, his M.S. and Ph.D. in 2008 and 2012 respectively from the University of California San Diego. Currently, he is on the faculty of Mechanical Engineering at the University of Massachusetts Lowell.

His research interests include dynamics and vibration, intelligent systems, signal processing and machine learning, condition-based monitoring of manufacturing and infrastructures, risk analysis, statistical modeling and prognosis.

Dr. Mao has published over 90 papers on top tier journals and internationally-recognized conference proceedings. He is currently the Chair of the Technical Division of Model Validation and Uncertainty Quantification at the Society for Experimental Mechanics (SEM), and on the editorial board of *Experimental Techniques*. He is elected on the Advisory Board of the International Modal Analysis Conference, and is on the Program Committee and serves as the Session Chairs for the SPIE Smart Structures/NDE conference, International Modal Analysis Conference, International Conference on Digital Image Correlation and Noncontact Experimental Mechanics, and the World Conference on Structural Control and Monitoring.