**Machinery Diagnostics with Physics and Machine Learning: A Perspective from Two Decades of Research**

**C. Nataraj, PhD, FASME**

Moritz Endowed Chair Professor in Engineered Systems

Director, Villanova Center for Analytics of Dynamic Systems (VCADS)

Villanova University, Villanova, USA

<http://vcads.org>

Modern machinery are nonlinear and complex, and identification of underlying faults is of paramount importance to avoid unscheduled downtimes and catastrophic failures. Further, as we increase automation the burden of additional reliability requires higher accuracy and confidence in our ability to find hidden faults and to map out their future failure paths.

This then is the problem of *diagnostics*, which can be defined as the procedure of mapping the information obtained in the measurement space to the presence and magnitude of faults in the fault space. For almost two decades, we have been developing and exploring diagnostic techniques which are fundamentally based on extracting appropriate features of *nonlinear* dynamical behavior of machinery systems and using a hybrid combination of physics and machine learning. The intention is to combine the rigorous and mechanistic methodology of model-based reasoning with the statistical strength of data-driven techniques in order to improve performance measures, including consistency with physics, accuracy, generalizability, and extrapolation capability. We have developed a spectrum of methods which I will discuss in this talk.

**Biography**

Dr. C. Nataraj (Nat) is the Moritz Endowed Distinguished Professor in Engineered Systems and the Founding Director of the Villanova Center for Analytics of Dynamic Systems (<http://vcads.org>) at Villanova University. Nat has served as Chair of Mechanical Engineering, and the founding Director of the [Center for Nonlinear Dynamics & Control](https://www1.villanova.edu/villanova/engineering/research/nonlinear-dynamics-control.html). Nat has developed and taught over 23 courses and has been a university runner up for the *Outstanding Teaching Award*. He has published a text book and 250+ peer-reviewed papers in dynamic systems, is a *Life Fellow of ASME*, the **Editor-in-Chief** of Springer-Nature’s [*Journal of Vibration Engineering Technologies*](https://www.springer.com/journal/42417) and serves on the editorial board of three other international journals including [*Nonlinear Dynamics*](https://link.springer.com/journal/11071). Nat’s current research interests are in the intersection of physics-based engineering and machine learning with applications to mechanical, electromechanical and biomedical systems. He has received research funding from ONR, DARPA, NSF and NIH. Nat is the winner of the *Villanova Outstanding Research Award*. His research has received media attention including two [TEDx](https://www.youtube.com/watch?v=kP8yuT5ZYTQ) talks, and articles in [Forbes](https://www.forbes.com/sites/leahrosenbaum/2020/04/30/as-coronavirus-spreads-globally-these-researchers-are-designing-ventilators-that-cost-less-than-1000/#59abd8445cb2) and [Wired](https://www.wired.com/story/team-made-dollar500-ventilator-may-never-used/) Magazines. Nat is the Founding Editor for [Nodycast](https://nodycast.org), a new podcast on Nonlinear Dynamics.