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COMPUTERS ARE TALKING AND THE MACHINES ARE LISTENING: *HOW CYBERPHYSICAL SYSTEMS ARE CHANGING THE WAY WE CAPTURE WIND ENERGY*

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ABSTRACT:

Computer control isn't new — PID and digital controllers are pervasive in machinery. But what if something fundamental about the machine changes either because or in spite of the controller? The answer is that the machine talks back, and a conversation takes place that forever changes both the computer program and the machine that is listening. A system like this that is composed of both computational and physical processes is called a cyberphysical system when the salient properties of the system emerge from computational and physical interactions. Such interactions promise to deliver game-changing capabilities in the performance of transportation, energy, healthcare, and nearly every other sector of the economy.

Wind energy is among the prime candidates for cyberphysical systems technology because there are many threats to wind power that drive up the cost of renewable energy. For example, a 20 pitch error in one blade can result in as much as a 25% reduction in electricity production. Wake effects and shear web disbonds could also be better managed through the codesign of computational models/algorithms and physical sensor/control systems that work together in wind turbines. Experiments in a small-scale wind turbine are used to demonstrate a Smart Blade technology that uses inertial sensors which are installed at optimal locations along the blade to detect and correct for aerodynamic imbalances such as yaw error, resulting in a factor of two reduction in the amplitude of fatigue loads to the blades. Operational modal analysis algorithms are used to identify features for yaw error detection consisting of modal contributions in the operating response of the rotor system. The detection of cracking in blades is also demonstrated using computational algorithms that exploit nonlinearity in the underlying damage mechanisms. Through the use of these onboard algorithms, evolving conditions in the rotor can be detected and corrected to not only maximize the energy captured by the wind turbine but also simultaneously extend the service life of the turbine machinery.

BIOGRAPHY:

Dr. Adams is Distinguished Professor and Chair of Civil and Environmental Engineering at Vanderbilt University and Professor of Mechanical Engineering. His research in structural prognostic and health management aims to identify unique signatures that illuminate the curious ways in which materials and machines degrade and then embed sensor and decision-support technologies into these systems to prevent failure in energy, security, and manufacturing applications. He has conducted over 100 sponsored programs, written 240 technical papers, and authored a textbook on structural health monitoring as well as several book chapters, including recent chapters on damage prognosis of aerospace structures, structural health monitoring of wind turbines, and monitoring of civil infrastructure. Research awards he has received include the Presidential Early Career Award for Scientists and Engineers and Society of Experimental Mechanics DeMichele Award, and he was elected a Fellow of ASME in 2011. He has supervised 55 M.S. and Ph.D. students and 35 undergraduate research assistants, and now advises 5 graduate students