System and Method for Diagnosing the Nature and Magnitude of Faults within Dynamic Systems

Lead Villanova University Investigator

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Background and Unmet Need

Complex rotating machinery is an integral part of operations across multiple industries including healthcare, medical device, robotics, and traditional manufacturing.

Turbomachinery, generators, engines, pumps, servo actuators, and electrical motors all depend on intricate inner mechanisms. Rotating machinery, such as turbomachinery, generators, motors, centrifuges, aircraft engines, pumps and fans, fail often because of bearing defects. Engines, gear-trains, servo-actuators, servo-valves, electrical motors often fail because of gears, cracks, and defective valves. Even a small fault or defect can result in a catastrophic failure.

Operations leaders need to detect defects and the magnitude of the defects before they progress to a point of catastrophic failure. Early detection of even the most minute machinery fault is critical for improving the longevity and performance of the machine. And in some cases, early warning of mechanical defects can save lives by avoiding catastrophic failures.

The inherent nonlinearity of dynamic systems makes diagnosing faults generally difficult but many industries implement complicated fault detection systems.

The current fault diagnostic systems typically rely on a series of sensors calibrated to monitor the performance of different parts in the machine. When a sensor detects a part is operating outside its normal performance range a warning is sent to the operator. To inspect the dynamic system, a user may have to take the dynamic system offline and to disassemble the system to perform the inspection. A mechanic or operator must then access the faulty part and determine the nature and magnitude of the defect. This process slows operations and requires skilled human labor, adding to operating costs.

A noninvasive method of fault detection, such as the Nataraj system, can provide operators with information about both the nature and magnitude of a fault without need for inspection or disassembly as well as provide advance warning of catastrophic failure. The invention accomplishes this task in a noninvasive manner without stopping the machine's operation or any kind of disassembly.

Opportunity

Fault detection and diagnosis is essential across diverse industries. They increase safety and reduce costs, replacing current scheduled-based maintenance strategies which cost billions yearly.

Dr. Nataraj's fault detection system invention provides a software-based method for diagnosing the nature and magnitude of faults within dynamic mechanical and electrical systems. The software uses measured data from already existing fault detection sensors and computes, with high accuracy, the possibility that there is a defect, such as a bearing defect or shaft crack defect, in the system; the algorithm also estimates the magnitude of the fault. It accomplishes this using mathematical analysis, nonlinear dynamics techniques, time series analysis, signal processing

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and machine learning. The software has been tested in multiple mechanical systems and performed with near perfect accuracy. The software can be generalized to a wide variety of mechanical and electrical systems. Not only will this make systems such as engines and motors safer, it will also cut maintenance costs significantly by providing more detailed information noninvasively than current systems allowing inspections to occur when needed rather than on an automated schedule.

Dr. Nataraj offers a superior solution to fault detection and diagnosis at a much lower investment cost than current methods, such as regularly scheduled inspection. All that is required is small computer to connect to already existing fault diagnostic sensors.

Unique Attributes

- Unique algorithm that utilizes mathematical analysis, nonlinear dynamics techniques, time series analysis, signal processing and machine learning to diagnose faults in mechanical systems.
- Compatible with sensors already present in many mechanical sensors.
- Highly accurate, with 100% accuracy in laboratory setting, making machinery much safer by providing a higher confidence level than exists currently.
- Generalizable to many different mechanical and electrical systems.

Applications

Diagnosing the nature and magnitude of defects in electrical and mechanical systems, as well as in components of these systems, including gears, servomechanisms, and motors.

Applicable within the healthcare, medical device, robotics, and manufacturing industries.

Stage of Development

Proof of concept developed and tested with algorithms.

Intellectual Property

US Patent 12,045,047 issued July, 2024.

Licensing and Collaboration Opportunity

Villanova is seeking a licensee or collaborators to commercialize the invention.

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