Analytics-at-scale of Sensor Data for Digital Monitoring in Nuclear Plants

PI: Vivek Agarwal - INL

Program: NEET 2.2: Big Data Analytics and Applications to Improve Plant Operation and Control

Collaborators: Ahmad Al Rashdan – INL;
Ronald L. Boring – INL; P
radeep Ramuhalli – PNNL;
Michael Taylor – EPRI;
Scot A. Greenlee – Exelon Generation Company, Exelon

ABSTRACT

Advancements in sensors, communication protocols, data analytics, and visualization technologies are redefining (and reshaping) the economics of operation, plant performance, and maintenance activities within the power industries. The nuclear industry is currently moving towards digital innovation to (1) address the Nuclear Energy Institute's Delivering the Nuclear Promise Initiative; (2) support life extension of the current domestic nuclear fleet beyond 60 years via improved plant performance; and (3) stay competitive in the domestic energy market. Development and implementation of wireless sensor technologies and data analytics for predictive maintenance are both critical and enabling for this purpose.

This project will address an unsolved challenge in the area of digital monitoring, i.e., the application of advanced sensor technologies (particularly wireless sensor technologies) and data science-based analytic capabilities, to advance online monitoring and predictive maintenance in nuclear plants, and improve plant performance (efficiency gain and economic competitiveness). Specific project objectives are: 1) Design a general methodology for techno-economic analysis (TEA) of wireless sensor modalities for use in monitoring equipment condition, especially in balance-of-plant systems in a nuclear power plant; 2) Apply data science-based techniques for decision making and discovery, to develop integrative algorithms for diagnostic and prognostic estimates of equipment condition using a combination of structured and unstructured heterogeneous data distributed across space and time, including new data from wireless sensors in a nuclear plant; 3) Develop a visualization algorithm to present the right information to the right person in the right format at the right time; and 4) Validate the developed approaches and algorithms using independent data from an operating plant.

The project will develop a TEA framework, with wireless vibration sensors used as a case study. TEA will enable identification of a wireless vibration sensor that is a best-fit for installation at the plant site. In parallel, the research team will develop feature-level integration algorithms using existing unstructured heterogeneous data distributed across space and time, i.e., analytics-at-scale. Machine learning techniques will be applied to obtain diagnostic and prognostic estimates for decision-making and knowledge discovery along with the implementation of interactive and graph-based visualization tools. This crosscutting research will enable digital monitoring in nuclear plants by bringing together advances in both sensor technologies and data science-based analytic techniques. The capabilities developed in this project are applicable to next generation reactors, fuel cycles, and other aspects of reactor operations and maintenance. The resulting technology is expected to improve plant economics by enabling the transition from periodic maintenance to predictive maintenance. Predictive maintenance will allow plants to better prepare for upcoming maintenance activities by optimizing allocation of resources including tools and labor, resulting in economic benefits and addressing safety by performing timely maintenance and preventing undesirable asset failures and associated consequences.