GuArDIAN: General Active Sensing for conDItion AssessmeNt

PI: Wilkins Aquino, Duke University

Collaborators: Michael Zavlanos – Duke University, Gregory Banyay – Westinghouse, Timothy Walsh – Sandia National Laboratories

Program: RC-8.2

ABSTRACT:

The goal of this project is to develop a dependable, autonomous or semi-autonomous (i.e. low human involvement), and minimally disruptive framework for monitoring equipment and components in nuclear reactors. One of the main challenges in monitoring components or structures is to obtain sufficient information through sensing so that reasoning systems can unambiguously detect and diagnose anomalies. Information obtained from a component or structure is usually limited due to sparse and static sensor networks. Hence, a framework that explores the states of a system (e.g. damage or abnormal behavior) not only through sensing, but also providing an optimal sequence of physical tests would be highly valuable as it could increase the reliability of the identification process.

We propose to develop GUARDIAN; a robust active sensing framework through the integration of model-based inference and mobile actuating/sensing robots. Our approach is to address the monitoring problem from a holistic view in which inference from data and data acquisition (i.e. actuation and sensing) are tightly integrated. Our system will be general enough that could be adapted to various monitoring problems where operational anomalies are to be detected under uncertainty. Our main idea is a two-legged framework that is composed of: 1) Robust computational inverse problem techniques, and 2) sensing and actuating mobile robots controlled by motion planning driven by 1). These two components will be integrated in feedback loop.

Although our framework is general and can be adapted to many anomaly detection problems, we will concentrate on damage and sound localization as concrete examples. To the best knowledge of the authors, the proposed framework will be the first of its kind. However, its development will present significant theoretical, computational, and practical challenges that will need to be addressed in this project. Our project will integrate physics-based simulators with active sensing using mobile robots, which will be achieved through the following research components: 1) High fidelity modeling of nuclear reactors components, 2) Model-based anomaly detection algorithms, 3) Distributed active sensing using autonomous robots, 4) Reduced order models for deterministic and stochastic problems, and 5) Demonstration of technology using high fidelity simulations and laboratory experiments.