Real-time Health monitoring of Gas Turbine Components Using Online Learning and High-dimensional Data

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Introduction

Big Data analytics holds enormous potential for enabling reliable operation of power generating gas turbines and combined cycle plants.

The objective of this research is to develop a Big Data analytics framework for critical gas turbine components through systematic experimentation that leverages unique industry-class turbine test rigs.

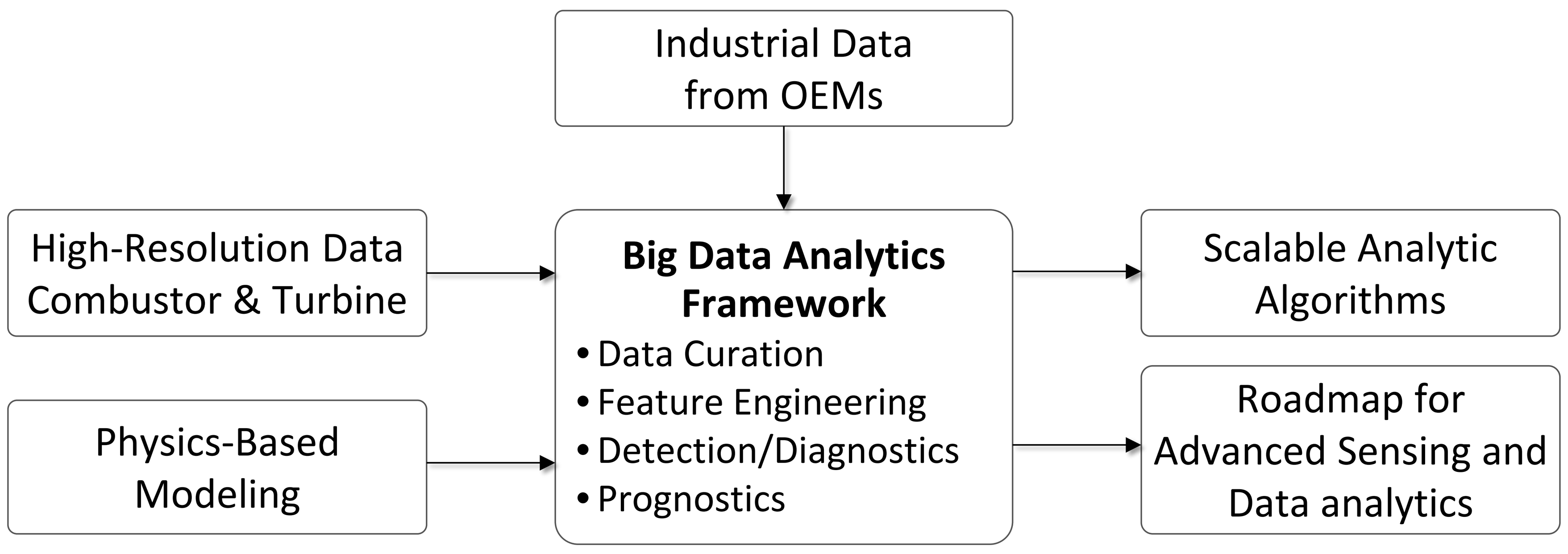

Figure 1. Research Objective, Scope, and Deliverables

Experimental Plan

The Big Data analytics framework will provide the tools for synthesizing large volumes of data, extracting key fault features, and performing robust fault detection and life predictions. This will be supported by an extensive design-of-experiments that utilizes unique **industry-class testing facilities** at Georgia Tech and Penn State University, which target critical combustor and turbine faults.

Combustor Faults

Damaged Combustor Lining
Temperature distributions, flow field features, and combustor acoustics.

Altered Combustor Flow Paths
Measure flame stability, emissions, and acoustics in a combustor

Combustor Blowout
Emissions and acoustics data, to develop LBO signatures

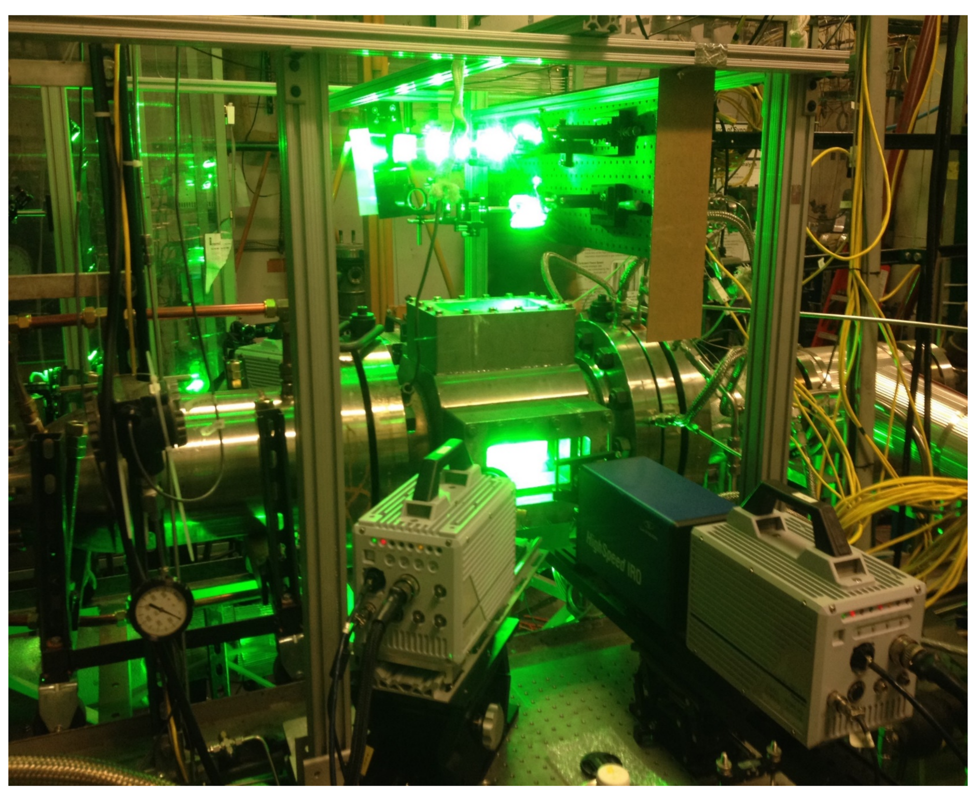

Figure 2. Georgia Tech Combustor Fault Rig

Turbine Faults

Inlet Temperature Transients
Spatially-resolved and time-resolved blade temperatures

Blade Coolant Loss
Spatially-resolved and time-resolved heat flux

Inter-stage Sealing Loss
Sampling of CO_2 tracer gas

Blade Tip Clearance
Clearances adjusted by shaft placement; clearance probes

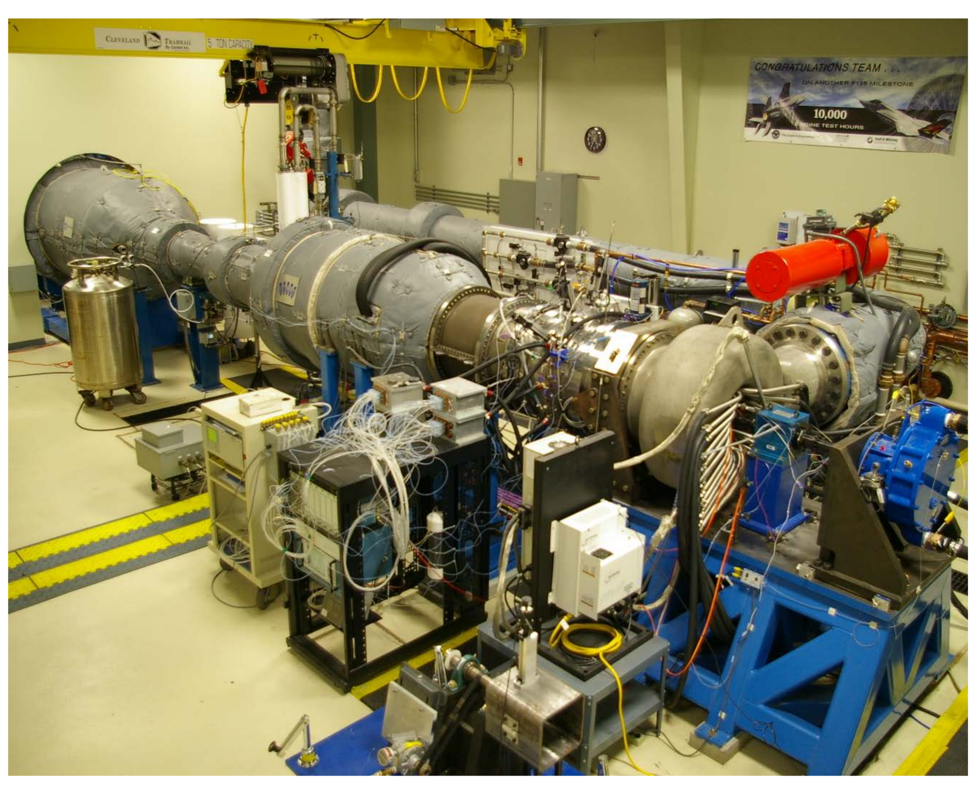

Figure 3. PSU START Turbine Facility

Big Data Analytics for Gas Turbines

The proposed Big Data analytics methodology consists of four key components shown in Figure 4.

- Develop **Data Curation Procedures** that tackle data storage, data quality assessments, and integrity checks.
- Develop **Feature Engineering Tools** using physics-based models to guide data transformations and develop high-fidelity fault features
- Develop Machine learning-based **Fault Detection and Diagnostics Algorithms** that guarantee low false-alarm rates.
- Develop **Prognostic Models** for predicting and continuously updating remaining operational life of critical gas turbine components.

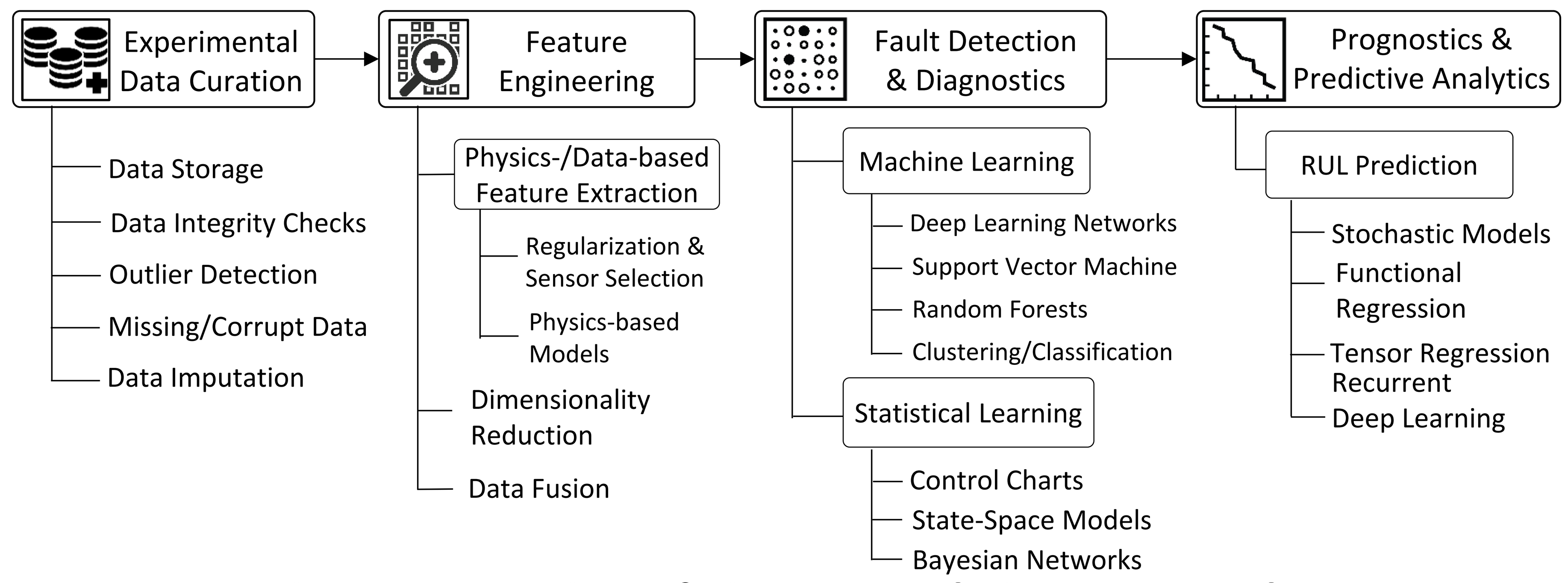

Figure 4. Overview of Big Data Analytics Framework

Cloud-Based System Architecture

- A cloud-based architecture will be utilized for storing, sharing, and performing computations on Big Data.

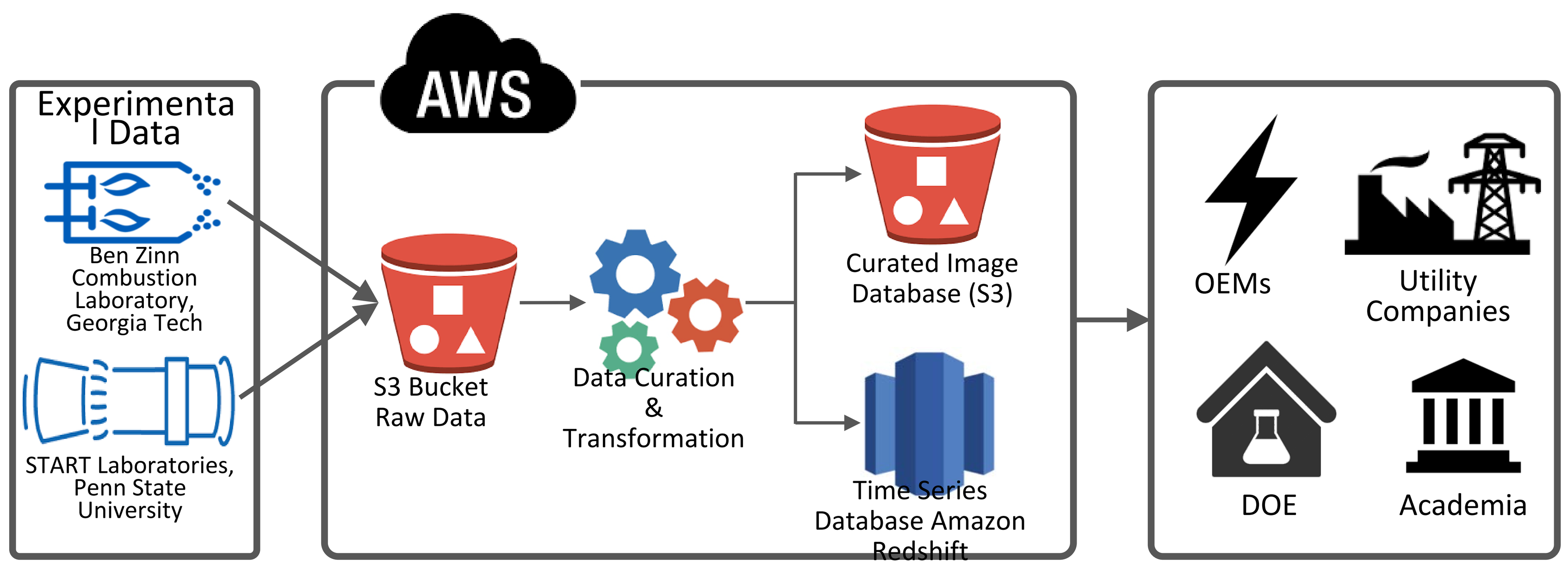

Figure 5. Cloud-based System Architecture

Deliverables and Collaborative Opportunities

- In collaboration with our industry partners, the project is intended to generate public domain, industrially relevant data sets that the broader community can explore.
- Please contact us if you are interested in generating proprietary data sets and/or testing proprietary hardware that leverages the approaches developed in this program.

Acknowledgments

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