Applying Domain Expertise and Machine Learning Techniques to Provide Actionable Solutions

Diesel Engine Signature Analysis and Anomaly Detection Case Study

MPR meets its client's challenging problems with the ability to combine historically acquired expertise and domain knowledge with new, cutting-edge methodologies and techniques. Delivering engineering excellence, MPR uses the application of Artificial Intelligence (AI) and Machine Learning (ML) techniques to diesel Engine Signature Analysis (ESA).

01 THE CHALLENGE

What is an Energy Signature Analysis (ESA)?

ESA's are routinely performed as part of condition-based maintenance programs for Emergency Diesel Generators (EDGs) across the nuclear industry. Hand-held equipment collects engine cylinder pressure, vibration, and ultrasonic signatures on every cylinder during loaded generator operation. MPR engineers then analyze engine signature data to identify the engine's degradation of cylinder components. Identified issues can then be rectified by the EDG operator through repairs or adjustments, thus ensuring the long-term reliability of the EDG.

Traditionally, ESA data is analyzed manually by MPR Subject Matter Experts (SMEs), however parsing through ESA data is a time-consuming process requiring a trained eye. The absence of such expertise can misinterpret the data. Modern techniques such as ML and AI can help engineers interpret large amounts of data for particular applications, such as ESAs.

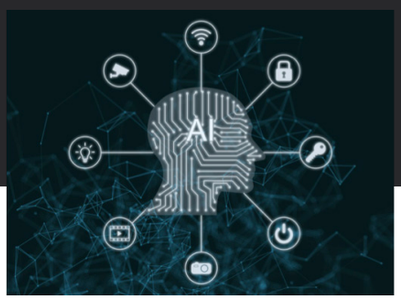
02 THE SOLUTION

ML/AI-Driven Coupling

MPR has effectively applied ML/AI techniques to assist SMEs in interpreting ESA data. MPR used modern tools such as TensorFlow to develop a Deep Neural Network (DNN) to interpret ESA data which would traditionally require manual interpretation. The solution involves two DNNs, an anomaly detection engine to identify issues in the time-aligned sensor data and a recommender engine to recommend solutions to remedy the anomaly. The DNNs trained using 20 years of diesel engine sensor data collected and interpreted by MPR in executing hundreds of ESAs. Historically, MPR SMEs identified the most relevant data to collect that yields the most efficient and impactful analysis and optimum repairs and adjustments that yield the best value. SME insights are integrated in the anomaly detection and recommender engines. This coupled approach has multiple benefits:

1. **Time**: Time spent analyzing ESA results reduced
2. **Efficiency**: The ML/AI tools could catch anomalies that would go unrecognized. Conversely, SME feedback to the DNN improves the tool.
3. **Accuracy**: The ML/AI tool assists SMEs in interpreting ESA results, serving as a second set of eyes on a complex dataset.
4. **Knowledge**: The ML/AI tool aggregates years of SME expertise and knowledge into a single, executable program, usable for years to come. This allows MPR to retain and advance the accrued knowledge of a highly specialized field.

Without deep domain knowledge in the topic area such as diesel engines, ML/AI models provide opaque results potentially without a firm rational foundation. MPR believes that deep domain knowledge coupled with well-designed ML/AI algorithms can add new levels of value to the most challenging engineering problems.



03 THE RESULTS

Future Applications

Over 2.5 million terabytes of data is created daily. Advanced data analytics offer an opportunity to capitalize on data creation. Coupling subject matter expertise and ML/AI techniques is the key to creating value from this abundance of data. The joint ML/AI and ESA methodology represents one example of coupling ML/AI tools with MPR SMEs.

MPR has expertise in industries where substantial amounts of data exist. As a result, MPR plans to continue expanding ML/AI tools into its engineering solutions, leading these industries in cutting-edge, highly technical solutions. The diesel ESA is a straightforward example of what MPR can offer in terms of advanced data analytics and shows the limitless potential of ML/AI in industry.

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