Engine Failure (Misfires)

LinePulse Case Study

Objectives

- Improve hot and cold engine testing through better failure classification
- Demonstrate LinePulse's accuracy and generalizability across engine types

Challenges

- Large, heterogenous dataset taken from testing 12 different engine models
- Significant signal variation due to dynamometer testing procedure

Results

- LinePulse Discover successfully identified the indicators of engine misfires in real time
- LinePulse Diagnose extracted 91% of engine misfires from historical data after less than a week

Learn more at:
https://acerta.ca

Background

A Tier 1 automotive supplier specializing in engine testing requested Acerta's assistance in enhancing its engine dynamometer testing procedures with machine learning. The client's goals were to identify previously unseen failure modes and accelerate root cause analysis of engine failures. Since the existing testing regimen required both cold and hot tests, the client was also hoping to leverage machine learning analyses of cold test data to reduce the need for hot engine tests, which are inherently more time- and resource-intensive.

The Problem

Since the client tests numerous engine models under a variety of different testing conditions, their data was more diverse compared to data from OEMs. Acerta received a large, heterogeneous dataset drawn from dynamometer tests of 12 different engine models from 4 manufacturers. These engines had been tested under a variety of driving conditions to evaluate their full range of performance.

The signals collected from 50 different sensors exhibited dynamic behaviour and significant variation, making it especially difficult to identify genuine failures. The testing data was also distributed across multiple files for individual engines and tests. From this data, we needed to determine the variations between different engines undergoing the same test and variations within a single test cycle.

Solution Process

Acerta began by merging the client's files and identifying labels that could be used to distinguish different engine models and different stages in the test cycle. Once data transformation and cleaning were complete, our data scientists were able to begin applying LinePulse Discover for modelling and feature engineering. Relevant features included correlations between engine performance and air-fuel (A/F) ratio, as well as relationships between levels of H_2, CO, CO_2, and NOx. In addition, signals that are not generally related to engine failures, such as atmospheric pressure, were de-emphasized. We trained our machine learning models on engines during normal operation only, which enabled LinePulse Diagnose to identify anomalous behaviour in engines, for instance identifying misfires.

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Solution Process (cont.)

While engine misfires are most commonly associated with significant spikes in gas levels, the former does not always result from the latter. For example, spikes in A/F ratio, CO, and NOx can occur as the result of a substantial drop in engine RPM, rather than a misfire. LinePulse correctly identified these cases as normal engine operation. Similarly, LinePulse recognized sequences involving particularly high concentrations of H_2, CO, CO_2, and NOx as warm-ups, rather than misfires, based on their correlations with the engine's temperature. However, LinePulse correctly flagged changes in relations between A/F ratio and engine speed at approximately 3,500 RPM as indicating a lean misfire.

Results

Acerta was able to identify true misfires based on unexpected changes in the relationships between certain signals. After being trained on the client's normal testing data, LinePulse was able to detect a variety of engine issues in addition to engine misfires, accurately, automatically, and in real time. As a result, LinePulse Diagnose extracted 91% of historical misfires from an unlabeled dataset of over 100 engine tests. This enabled the client to increase reliability of their engine tests in addition to reducing the need for running hot tests.