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Case Study: Predicting ESP Failures With Variable Data Quality

PROBLEM

A major oil and gas company was trying to predict electric submersible pumps (ESP) failures **but had challenges with sporadic sensor data.**

SOLUTION

Unsupervised machine learning approaches, specifically normal behavior modeling (NBM) and clustering, **were determined to be the best way to predict failures** using the data available.

RESULTS

The two approaches would have **saved the company an estimated 45 and 27 days of lost production time**, respectively.

PROBLEM: INSUFFICIENT DATA FOR ESP FAILURES

Electric submersible pumps (ESP) are critical assets that are expensive to purchase, operate, and maintain. The average pump is worth roughly USD $100-150K, and a rig pull for maintenance may cost $300-400K even before factoring in lost production. This makes it crucial for oil and gas operators to find ways to predict issues with ESPs and take action before they fail.

One major oil and gas company was looking for a way to predict ESP failures but was struggling with poor data quantity and quality. Because ESP sensors may have been thousands of feet underground, it was often not feasible to fix broken sensors. Additionally, the ESPs were in a remote location without a stable electrical power source, leading to sporadic power outages that damaged the sensors and caused them to die more quickly. Compounding these issues, the oil and gas company had been running out of memory space for sensor data and, therefore, had stopped recording data from many of its sensors.

All of these factors seemed to present an insurmountable barrier to implementing predictive analytics for the ESPs. Analytics and machine learning require large amounts of clean data to produce good results, with minimal missing values. But by partnering with SparkCognition, an artificial intelligence (AI) solutions provider and expert in the AI space, the oil and gas company was able to avail itself to a wide range of possible approaches to AI-powered predictive maintenance, tailoring its implementation to the quality of data the company had available.

SOLUTION: TWO CUSTOM MACHINE LEARNING APPROACHES

The objective of this project was to construct machine learning models that could predict impending electrical or mechanical ESP failures in advance, thereby increasing asset life and helping maintain production standards.

To discover how best to address this problem using the data the company had provided, two different approaches were used.

Normal behavior modeling

Using a semi-supervised approach, normal behavior models (NBM) were trained to recognize normal, healthy operating conditions for each asset, using parameters provided by the oil and gas company's subject matter experts (SME), as well as patterns learned from historical data. The model that was created identified intake pressure, discharge pressure, intake temperature, motor temperature, current leakage, and wellhead pressure as the variables most predictive of abnormal behaviors, so these variables were used to identify periods of abnormal behavior that could lead to failure in the data.

Based on test data and the company's activities log, the model successfully identified 5 out 7 historical ESP failures 13 to 35 days in advance. This means the model could have saved 45 days of production from being lost to unscheduled downtime, or roughly $1.35 million USD in lost production.

However, because of the high number of electrical trips from the unstable power supply, the NBM approach was difficult to scale across a large number of wells, as the frequent power outages made it hard for the model to establish a model of normal behavior out of data that all appeared abnormal. Therefore, SparkCognition took a second approach.

Clustering and classification

For this approach, power trip intervals were removed from training data. Then wells were clustered based on reservoir zone to account for zonal differences. Then a supervised classification model was created to learn from all failure types across all 400 wells, and classify each well's current state as failure or not failure, based on its sensor data relative to other wells within its zone. The data most heavily used in the process included electrical sensors such as motor current, motor voltage, current leakage, and apparent power. Based on this model's average detection rate, it could have saved the company 27 days of lost production due to unscheduled downtime.

RESULTS: PREDICTIVE ANALYTICS FOR ANY OPERATION

Identifying ESP failures in advance allows companies to decrease well downtime, reduce the need for costly maintenance, and increase overall production. By working with an experienced AI partner, the oil and gas company SMEs was able to iterate through tailor-made models until they found an approach that worked for them, despite their lack of complete data.

Machine learning implementations for predictive maintenance are not out of reach, even with more challenging data sets. By bringing together AI expertise with in-house SMEs familiar with the assets and data, a whole new set of possibilities opens up, allowing operators to predict failures and prevent unplanned downtime for their assets in a way that meets their business needs, using the resources they have available.

ABOUT SPARKCOGNITION™

SparkCognition builds leading artificial intelligence systems to advance the most important interests of society. We help customers analyze complex data, empower decision making, and transform human and industrial productivity with award-winning machine learning technology and expert teams focused on defense, IIoT, finance, and oil and gas.

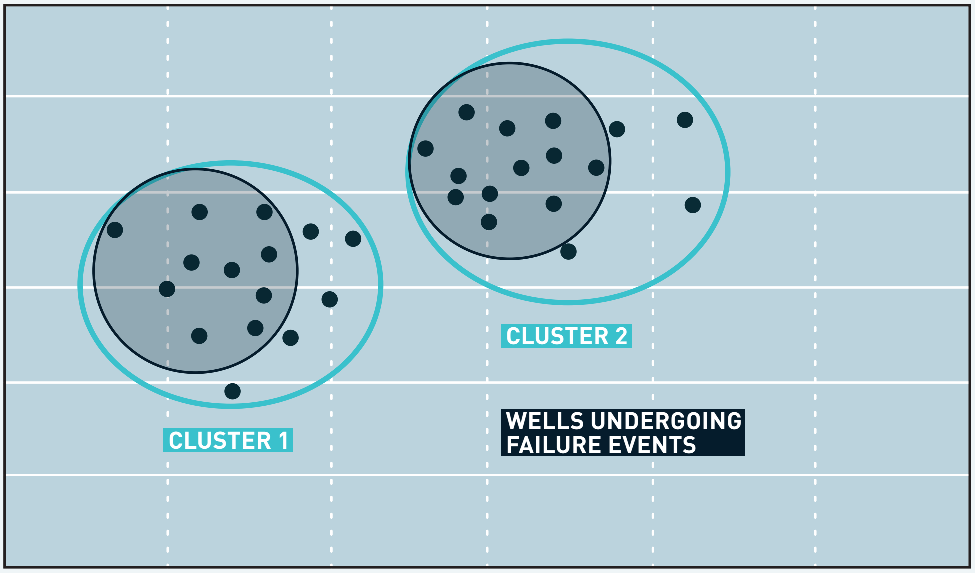

FIGURE 1

In this example visualization, individual wells (represented by dots) are first clustered by reservoir zone. The model then classifies each well's current state as failure or not failure based on its sensor data relative to other wells within its zone.

Contact SparkCognition today at info@sparkcognition.com