Energy Multinational Saves Millions with AI

INDUSTRY

Energy - Oil and Gas

GOALS

- Analyze time series sensor data to identify and predict failures
- Develop a statistical behavior model for correlating top-side and down-hole sensor data
- Reduce drilling failures and unexpected downtime with a predictive failure model

SOLUTION

2predict developed a neural network sequence model that helped identify and predict drill bit failures.

RESULTS

- Identified data inconsistencies and developed new workflows to code and clean data
- Provided a statistical predictive model that can forecast drill bit failures
- Improved drilling penetration and completion rate times
- Reduced unscheduled and costly downtime

BACKGROUND

A Fortune 500, multinational energy corporation wanted to improve drilling efficiency by reducing drill bit failures and achieving better drilling penetration rates and completions. The client was experiencing extremely costly failures in well drilling and completions.

Already a leader in applying technology in its production processes, they installed a sophisticated system of sensors to collect time series data during drilling. But, they were unable to extract learnings from the data that could help prevent costly down-hole drill bit failures. The company assembled a task force and enlisted the help of advanced analytics solutions provider 2predict, who developed a statistical model that provided insight and enabled advanced warning of impending drill bit failures.

2predict

Advanced Analytics Solutions

Challenges

WHAT WAS CAUSING EQUIPMENT TO FAIL?

When a drill bit fails, the company loses hundreds of thousands of dollars a day in rig downtime. This downtime, along with time spent retrieving and replacing the drill bits, prolongs time to revenue. The wells are thousands of feet deep vertically and horizontally; crews need to pull the equipment back to the surface when a drill bit fails to replace it. Each leased rig costs approximately $20,000 to operate daily – any downtime is a significant loss.

The company's leadership put in place a sophisticated – and quite costly – data acquisition system in 30 of its wells in the Midwest to collect and analyze down-hole data. They hoped to determine what was causing drill bits and other equipment to fail, and to improve drilling efficiency and well completion activity.

THE NEED FOR A MODEL TO CORRELATE SENSOR DATA

However, sensor placement proved challenging. "Down-hole" sensors placed right above the drill bit are expensive and complex to set up, and don't report real-time information. The drill bit grinds through various types of rock at high temperatures and pressure, and is constantly rotating and vibrating. Installing permanent gauges that collect data while drilling is necessary.

A better option is to collect data at the surface and use this data to correlate and model down-hole drilling behavior. Here sensors can provide real-time information about:

- How fast the bit is turning (RPMs)
- Weight on bit, hook load
- Various types of torque and resistance encountered during drilling
- Amount of vibration at the surface
- Mud motor (the motor that drives the drill string) stresses

Using this information, operators can steer drilling operations to drill and complete a well as fast as possible while preventing failure.

The task force had the data, but no model for analyzing it or correlating what was happening at the surface and down-hole. The team lacked advanced expertise in machine learning (ML), which limited their ability to develop such models. 2predict was brought on to interpret and analyze available subsurface data, model that data, correlate top-side and down-hole data and improve penetration rates.

> "In under two months, we were able to solve their initial problem by providing a model that could correlate surface measurements to down hole signals on the lateral vibration."
>
> -- Cedric Fraces, Lead Data Scientist, Reservoir Analytics at 2predict, Inc.

The Solution

The project was delivered in four phases, over roughly six months:

PHASE 1: DISCOVERY AND PLANNING

Data scientists at 2predict worked with the task force to collect, understand and analyze roughly 1.5 TB of time series data. Sensors in the wells collected data across 100 different channels, such as pressure, horizontal and lateral vibration, RPMs and more, every millisecond for each of the 30 wells involved in the pilot.

The task force consisted of several professionals with various backgrounds, such as database experts, engineers and geophysicists. The team was initially interested in "mud motor" failures, which occur at certain lateral vibrations and through "stick slip" events. Stick slip events occur when a bit gets stuck in less consolidated rock.

"In addition to reducing bit failures, we wanted to improve operations," said Cedric Fraces, Data Scientist, Reservoir Analytics at 2predict, who co-led 2predict's efforts. "We wanted to understand what drives penetration rates and prescribe solutions to increase them, or predict drilling failures two minutes before the breakpoint to enable corrective action."

2predict held a kickoff workshop with the task force to understand the datasets, followed by a series of teleconferences and phone calls to dig deeper and identify inconsistencies. The company's task force had been unsuccessful in solving the bit failure problem by focusing on lateral vibration, despite asking two major oilfield service companies to look into the issue. In fact, they were told it was not possible to make such predictions.

2predict set to work using statistical learning techniques to analyze the sensor data for insights and reconstruct a story of drilling operations.

PHASE 2: HYPOTHESIS AND MODEL CREATION

Next, 2predict created a model that would correlate what happens at the surface with what happens down-hole. The model was a based on "sequential neural networks," which is well-suited to time series data.

They presented a set of new analytics and KPIs to the client and built a new database using an efficient compression format – Apache Parquet – and MySQL connected to an interactive dashboard. The dashboard allowed for rapid demonstration of the drilling performance issues that were regularly updated and used to support technical discussions.

PHASE 3: MODEL TRAINING AND REFINEMENT

During this phase, the models were trained. 2predict first used a set of synthetic data to create models that helped build confidence that the architecture and methods were appropriate for the dataset size and dimensionality.

The synthetic models consisted of classification tasks, during which a specific signal signature was associated with certain events – mostly highs and lows for the overall drilling activity. These made it possible to:

- Establish that gated recurrent networks with a certain size and considering a given sliding window width were appropriate.
- Test out various techniques of data augmentation, initialization and optimization.

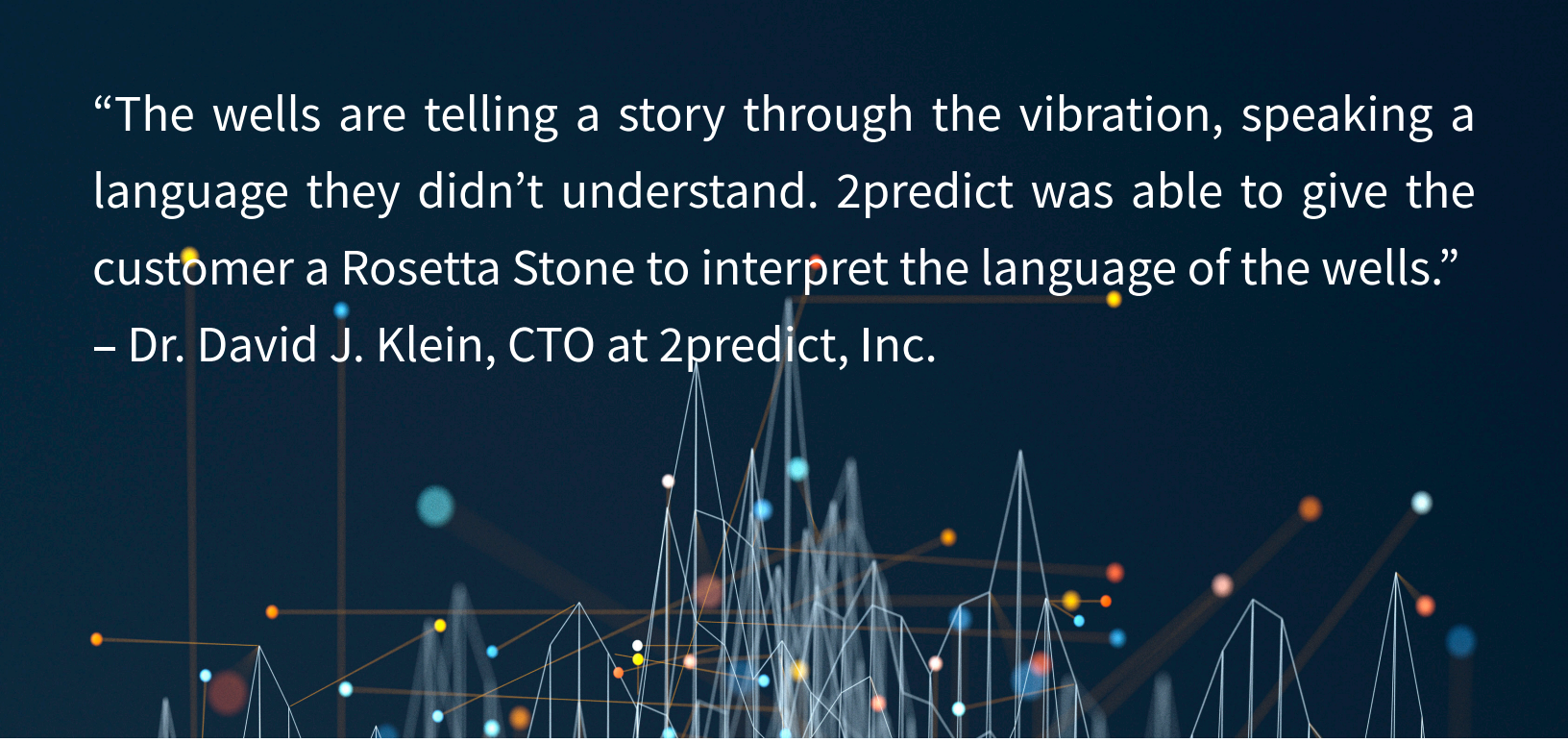
As raw data from sensors tends to be noisy, an important preprocessing step was to de-noise the original data. The team used a combination of Savitzky-Golay smoothing and discrete wavelet transform to make the data more amenable to the LSTM networks. This treatment drastically improved the predictive performance of the algorithms.

The 2predict team then selected a set of template architectures to use for more advanced problems. One of the first practical models was to replicate the result of rig state classification using a learned approach, rather than a set of hard-coded rules – an LSTM architecture with two layers of 48 units, and a dropout rate of 0.2. The output was the classification of the whole time series into a set of events – "drilling," "casing," "pulling out of hole" and "tripping in hole." Results were satisfactory, with an accuracy of 94% and an F1 score of 0.7. (These could have been further improved, but were not a priority for the study.)

Next, 2predict built regression models to correlate surface and down-hole data using the Tensorflow library. The models were then trained on servers with GPUs and delivered to the customer.

PHASE 4: KNOWLEDGE TRANSFER

2predict streamlined workflows for data preparation, to enable cleaner data with fewer inconsistencies, and delivered a set of notebooks for knowledge transfer. The last step was to migrate the architecture, so the task force could continue using the new predictive models on their own. 2predict's intuitive dashboard eliminated the need for multiple, disparate spreadsheets.



"The wells are telling a story through the vibration, speaking a language they didn't understand. 2predict was able to give the customer a Rosetta Stone to interpret the language of the wells."
– Dr. David J. Klein, CTO at 2predict, Inc.

RESULTS

2predict helped the company in the following ways:

- They identified data inconsistencies that lead to suboptimal operations and can now take action to correct them.
- They can apply new workflows and code to clean their data.
- They learned how to tackle problems related to drilling using deep learning technology.
- They have a better understanding of how they're performing against industry-standard KPIs.

The new predictive models will help prevent costly drill bit and other equipment failures. Based on past failure rates across the 30 wells used in the pilot, the customer loses approximately $150,000 due to downtime per well – and that's a conservative estimate. Reducing such failures by just 50% across 200 wells can save about $15 million.

The project was deemed a success, and 2predict's delivery represents a considerable return on investment for the client and sets a new industry standard in its leading-edge advanced analytics investment.

ABOUT 2PREDICT

Located in Silicon Valley with European operations, 2predict provides advanced analytics solutions that leverage AI techniques and algorithms to uncover interesting insights and create predictive models from a company's big data. These data models help clients identify opportunities for making operations more efficient, cut costs and generate additional revenue.

Learn more about how 2predict can provide your organization insights into your data.

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