Predicting Incipient Failures in High-Pressure Fluid-Filled Underground Cable Systems

Startup
Eneryield
Gothenburg, Sweden

Host
NYPA

Technology Solution

High-pressure fluid-filled (HPFF) cables underpin the majority of U.S. underground transmission systems, and many of these cables are reaching or have exceeded their design lifetime of 40 years. Innovative methods for detecting incipient cable failures are needed for preventing high-impact events, improving reliability, and optimizing asset management and maintenance interventions.

This project was initiated to test Eneryield's machine learning (ML) algorithms and other AI-based techniques for generating data-driven insights and predicting imminent disturbances or HPFF cable faults. Eneryield's proprietary AI/ML technology is being developed and applied in a variety of utility and industrial settings for maintaining system health based on insights that are not normally apparent when using conventional situation awareness and condition assessment methods.

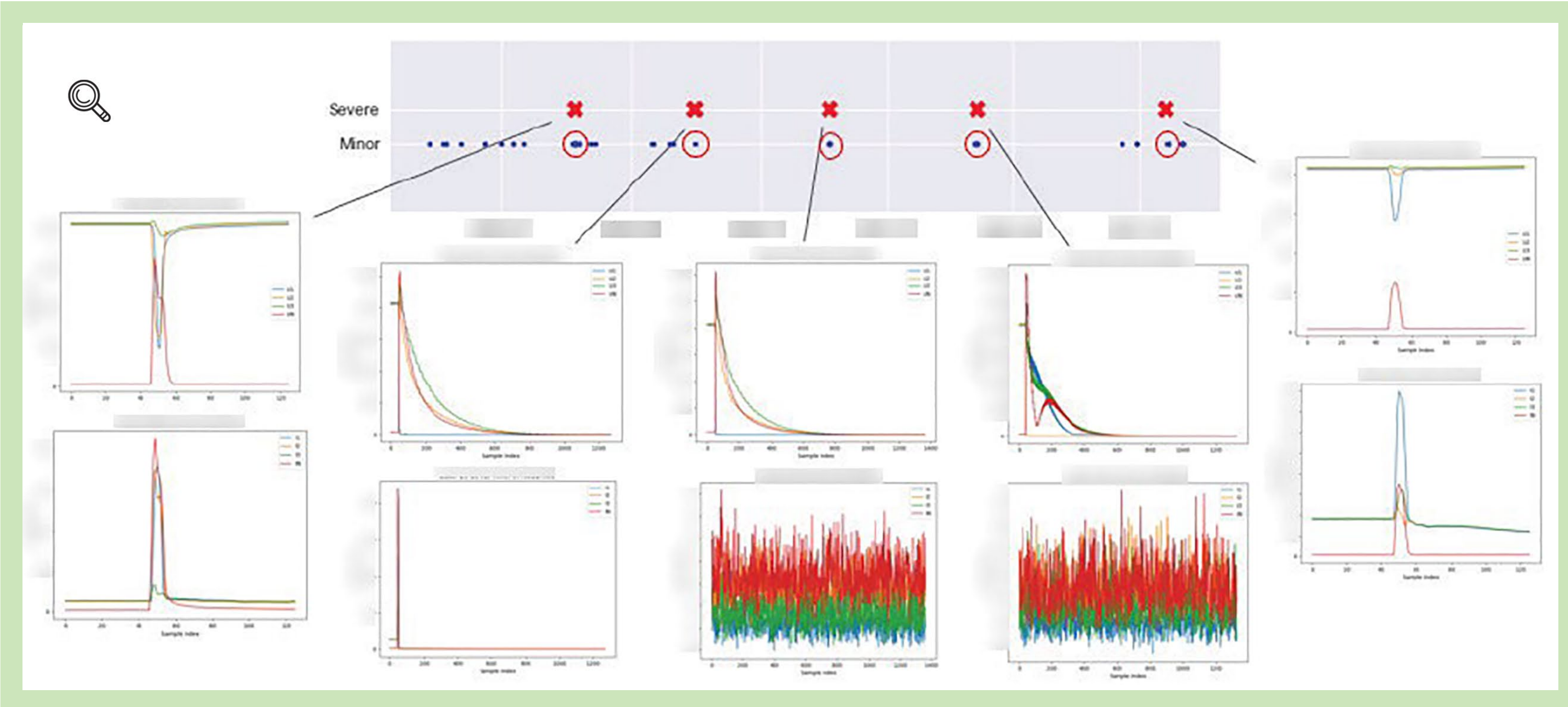
Project Overview

The project team from Eneryield, New York Power Authority (NYPA), and EPRI scoped out the demonstration to focus on collecting and combining historical data from various sources and applying AI/ML techniques with the goal of identifying small anomalies, deviations, and patterns that can be used to predict incipient but larger cable disturbances/faults with as long a time horizon as possible. Key research questions included the following:

- Can AI/ML techniques identify unique data correlations, indicators, and characteristics to help predict incipient failure of buried/underwater cables, going beyond the capabilities of more conventional analysis techniques?
- What are minimum data requirements for getting high value from AI/ML techniques in this application, what level of confidence can be assigned to specific uses, and what are key drivers?

Advanced analytics support early indication of incipient failures in underground/submarine transmission cables.

To support the project, NYPA facilitated access to data resources—including historical records from power quality meters, relays, and phasor measurement units—relevant to the condition and performance of the Y-49 cable system, an underground and undersea connector between Long Island and mainland New York. A total of 155 Comtrade-format data files were initially identified, of which 87 were found to have potentially useful data. The data were divided into two sets, the first used for training of the AI/ML system and the second for validation of its ability to predict faults before they happen using a blind data set from an existing Y-49 cable failure.



Data related to five distinct cable failure events were applied to train and assess the predictive capabilities of Eneryield's AI-based algorithms.

Results & Learnings

Much of the pilot project period was spent acquiring data resources relevant to the Y-49 cable's performance and its occasional failures, filtering and conditioning those data resources to make them useful, and conducting training. In the limited time available for applying AI/ML techniques to generate useful insights, Eneryield was able to identify several instances where clusters of events—including voltage unbalance and transformer saturation—appeared to pre-sage subsequent cable faults. In addition, the techniques were applied to characterize event type and location (upstream/downstream), identify correlations between events, and develop predictive capabilities.

Data related to five severe cable events were provided, including three severe faults used in algorithm training, one severe fault used in validation testing, and another event known to NYPA but not Eneryield. In addition, numerous minor events were identified and subsequently tested to see if they could be used to predict major events.

Preliminary results show that initial cable faults can be predicted within 2 months of occurring and with an 80% level of confidence. Even more impressive, subsequent faults following on the initial one can be predicted within 24 hours of occurring and with a near 100% level of confidence. Given the limited data sets available to the project, these results generally exceeded initial expectations.

Implications & Next Steps

This project's main objective was to test the ability of AI/ML techniques to discover useful information that would otherwise be invisible and, in particular, to apply these techniques to an existing underground transmission asset for incipient failure detection. A secondary objective was to see if the capability to predict failures before they occur is possible even in situations with limited data resources.

The project achieved success on both of these objectives, highlighting the potential for utilities to "know what is coming" and to prepare or take remedial action. Significant additional investigation and development are needed to increase the level of confidence in the results of Eneryield's predictive analysis and to better quantify the frequency of detection errors, including both false negatives (missed failures) and false positives. Further work is planned to focus on identifying additional data sources for training the AI/ML algorithm and for validating the level of confidence in incipient failure predictions.

Resources

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TESTIMONIAL: Eneryield

This project was valuable as a practical demonstration of Eneryield's AI-driven algorithms for supporting proactive maintenance to avoid serious cable faults that could otherwise lead to service interruptions, as well as damaged equipment.

TESTIMONIAL: New York Power Authority

The goal of this effort is ambitious—to develop a technology that can identify the precursors of underground cable faults, predict if and when a fault will occur, and determine the causes of failures. A system that can predict problems and identify causes could be invaluable in maintaining the resiliency of the transmission system not only for NYPA but other utilities as well.

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