

An Artificial Intelligence–driven MIRACLE for Condition Reports Screening and Processing



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Plant Modernization and Risk-Informed Systems Analysis

In the nuclear power industry, issues are documented in a condition report. Experienced staff members routinely spend tens of hours every week reviewing condition reports. The initial review process of reports typically involves five to 10 people reading each condition report, assessing its impact and priority, and deciding what actions need to be taken and by whom. Once that is done, the reports are categorized to keep track of common issues in the plant. For significant issues, multiple detailed follow-up meetings and evaluations are performed.

This process costs the United States (U.S.) nuclear power industry hundreds of millions dollars every year. In addition to all the time it consumes, the manual and subjective nature of the process means that there is always a chance for an issue to be overlooked or underestimated, or for a decision to be made in error.

What is MIRACLE?

Machine Intelligence for Review and Analysis of Condition Logs and Entries (MIRACLE) is an artificial intelligence (AI) tool that automates condition report handling, as observed in Figure 5. MIRACLE reads through tens to hundreds of table fields, including free-form fields, sifting through text, and evaluating it against what it learned from the training sets, as also can be seen in Figure 5. It rapidly performs multiple functions in a split-second that are typically performed by plant staff.

MIRACLE is based on advanced natural language processors and a combination of multiple custom-designed AI neural networks that classify items and replicate human decisions. MIRACLE has two core capabilities. It can classify condition reports in order of importance, safety significance, etc. This is usually based on training MIRACLE with a dataset that includes those in the form of labels for it to learn and replicate the process. MIRACLE can also perform unsupervised machine learning (ML) (i.e., learn without ‘labels’). It creates topic clusters (i.e., group of correlated words related to each topic) from

training sets generated from nuclear power plants across the U.S. MIRACLE creates a nuclear dictionary of all the possible topics that can be assigned to a condition report. Those topics can be tagged by ML to each condition report. For example, if the free-form text in a condition report describes liquid material that looks like oil found near a pump, MIRACLE can assign one or more topics (e.g., ‘leakage’) to it. Even though leakage may not be explicitly mentioned in other reports, because of its ability to understand context, MIRACLE automatically assigns this ‘leakage’ topic, along with other topics, to all reports that contain similar related issues. From this, it can sort incidents into specific event classifications that are used holistically to track a plant’s condition.

How is MIRACLE Different than Other Condition Reports Screening Tools?

Diverse Data Set: MIRACLE draws on data in condition reports collected from more than 25% of the nuclear reactors across the U.S., which potentially makes it a powerful tool in terms of accuracy and performance. This sheer mass of information gives MIRACLE unique functionalities, leveraging the data diversity to create scalable and easily transferable capabilities. A recent test of MIRACLE using data from two utilities proved significantly more accurate than using data from a single utility.

Topic Dictionary: MIRACLE has created a topic dictionary for nuclear power plants, that intelligently and automatically assign topics to condition reports. Data gathered from industry was used to create more than 100 categories of topics (e.g., badging, breakers, valves) that represent everything that can happen in a nuclear power plant. By this process, MIRACLE is consistent and systematic in assigning topics, which is a key requirement to making them useful in tracking performance.

Performance Tracking: The current industry approach is based on a simple search or filter rule and manual logging of specific occurrences of events to create a trend that is

time-consuming and limited. This approach is susceptible to missing or extraneous, irrelevant events. Through MIRACLE, topics are automatically assigned to every condition report. Staff can track how many times an issue occurs in a defined amount of time and trend it. If issues are on the rise at different operators' plants—or across the industry—this will help to direct attention to issues.

Flexibility: MIRACLE offers a flexible model that can work with any type of plant data with minimal effort required for data preparation. Without such data flexibility, each time a user applies AI or ML they would need to prepare data to supply it to the specific model. This makes MIRACLE easy to deploy, a key objective of its design.

Sparse Events: MIRACLE's use of industry-wide data overcomes specific plant data limitations or coding errors. This is important for events. For example, a 'safety condition adverse to quality' is a very important event, but

rarely occurs at most plants. Because it is such a rare event, it is nearly impossible to train an ML tool to reliably detect one. When data are combined across multiple utilities, however, MIRACLE may gain enough occurrences to train to classify such events accurately.

Conclusion

MIRACLE improves nuclear safety and reduces operating and maintenance costs by making systematic decisions. It can help plants reduce errors and eliminate significant time, paperwork, and meetings. By drastically reducing the hours each worker must spend reviewing and processing condition reports at nuclear plants, and by speeding up the time problems are identified and addressed, providing a broader perspective on plant and industry performance, MIRACLE offers a way for plant owners to improve efficiency and safety.

Figure 5. MIRACLE replaces significant review time, paperwork, and meetings performed by the humans within the overall work management process of a nuclear power plant.

