Predictive Maintenance: Using the Past to Super-Charge the Future

With each year of digitalization experience that passes, our data gets deeper, knowledge of our machines grows, and the insights we can glean from past performance enable us to more accurately foretell outcomes, optimize maintenance of our industrial assets, and super-charge our efficiency, just as the early advocates of Industry 4.0 predicted.
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Beyond the data deluge

By Sachin Andhare, global marketing director with Falkonry

In the quest to improve throughput, efficiency, safety and reliability of their operations, heavy industries are ramping up digital-transformation initiatives. Oil & gas, mining and metal companies are embarking on multyear journeys to digitize operations by adding connectivity, automation and data analytics.

According to McKinsey & Company, most heavy-industry sectors are at the middle stages of digital maturity (Digital 2.0), relying on rule-based automation and distributed control systems. Others have made progress in digital maturity (Digital 3.0) and use collaborative robots, advanced process-control systems and real-time optimizers.

However, a few digital pioneers are applying artificial intelligence (AI) and machine learning (ML) to operational data (Digital 4.0), which enables predictive operations.

So what can we learn from these digital pioneers? And how can companies apply ML across industries at scale?

DATA DELUGE
Manufacturing and process engineers need to review operational data across many sources such as ERP systems, MES, historians, computerized maintenance-management systems, etc. Due to the sheer volume and streaming nature of data, manual inspection and analysis is unsustainable. Often data from diverse systems comes in multiple units, formats and incompatible protocols. To get a better handle on data, companies have invested in building massive data warehouses, data marts and data lakes, but that has brought new challenges related to data governance and validation.

Industrial-operations teams need a scalable, robust, and high-performance environment for operational data management, review, learning and analysis.
INDUSTRY CHALLENGES
Applying AI and ML techniques to operational data has been challenging for a variety of reasons. Most AI/ML platforms are designed for data-science professionals, not the operations teams. These platforms are difficult to learn and cumbersome to use. Moreover, the standard ML process is complicated and laborious, with long lead times of 6–9 months. It involves data preparation, blending, feature engineering, algorithm selection, model training, testing and deployment.

Once built and tested, data scientists hand over these custom models to operations. There is little collaboration with the operations staff and the majority of data-science initiatives fail to achieve their objectives. Also, the output of these models lacks transparency and does not give the subject matter experts (SMEs) in operations confidence to trust the underlying technology in a production environment. These SMEs trust their “intuition” or gut feeling over any AI program and, hence, the custom models rarely get deployed beyond pilots.

PREDICTIVE OPERATIONS AT SCALE
The solution is an ML system designed and built for industrial operations; a system that is usable by operations teams without requiring additional resources. A collaborative ML system allows operational experts to leverage their domain expertise by providing relevant condition facts or labels based on historical data. Then, by using unsupervised and semi-supervised ML algorithms, the system finds patterns in production data, identifies deviation (in quality as an example) and empowers SMEs to prevent recurrence.

This ML system must hide the complexities, automating feature engineering and other onerous steps of ML process. To make ML transparent, it should quantify prediction and provide explanation and confidence metrics with details into model output. Explainable AI gives insight into predictions, allows users to understand signal correlation, and enables SMEs to understand which process variables affect outcomes for root cause analysis.

Industrial operation presents multi-dimensional problems, whether you are optimizing efficiency, preventing quality defects or reducing asset downtime. A domain-agnostic, prepackaged ML system offers analytical flexibility to address multiple use cases and dramatically improves the life of operational experts, as they don’t have to learn new tools for each new project.

This is the preferred approach among digital pioneers—it saves time, allows repeatable ML process and delivers superior ROI.

A collaborative ML system that automatically identifies patterns among hundreds of variables, delivers actionable insights and generates SME trust will enable predictive operations. And empowering operational SMEs is the way to achieve a Digital 4.0 maturity level in any industry at scale.
With the increased integration of AI and machine-learning technologies into industrial environments (such as smart factories), IT managers seek the best strategies for enabling all the benefits—tangible as well as potential—that will affect factory efficiency, now and into the future.

New capabilities like predictive maintenance are made possible by recent developments driving real-time insights generated from the data that’s being captured, processed and analyzed from all the connected machines, critical systems and other sensor-laden devices in the factory. The most common use case for machine learning in IoT is for predictive analytics, according to an IDC survey, where 83% of the respondents were developing predictive-analytics capabilities.

Optimizing use of this data requires IT managers to store, move, manage and properly utilize the data. But, what’s the best strategy to capture the necessary content (what it is and where it’s from) and context (why it’s important and how it can be used) of all the data coming in from all the connected devices at the edge?

The answer is tricky.

Take the factory environment as an example: a hybrid approach collects data from the edge and moves it up to the cloud. IT managers, equipped with the context they have for all the edge devices in the factory, can filter, dissect, organize and command this huge amount of data to determine the best ways to integrate and optimize AI technologies for the factory. In a smart factory, data is not funneled directly to the cloud because valuable factory-floor context can be lost in this transition. Additionally, latency, security and
data integrity are all considerations for accuracy and safety.

Instead, a new hybrid model is emerging where data is collected from all devices at the edge and stored on a local gateway equipped with necessary AI and machine-learning capabilities to perform the analysis, inference and other critical tasks in real-time, with lower latency and without some of the same security risks.

Data that’s kept on the gateway is sent to the cloud during off-peak hours when timeliness is no longer a concern. More machine-learning algorithms are performed in the cloud over time to produce patterns and insights that can be used for predictions and future operations.

The variety of sensors has multiplied in recent years, enabling granular monitoring of the entire factory. IDC predicts the number of deployed sensors to exceed 80 billion worldwide by 2025. Thanks to the leapfrogging advance in technologies from chipset to applications, the data generated by these sensors is put to great use. From a strategic business perspective, factories can enhance their operations and output through data analysis both at the edge and in the cloud. Data acted upon at the edge can prevent mishaps in the production line from a machine error, data sent to the cloud, or the “core,” enables long-term analysis of variance factors to render savings or heighten efficiency within the factory.

Machine-performance deviations can be detected (if not predicted), enabling factory managers to fix issues rather than reactively replacing—at great cost—faltering units. This mix of real-time analysis and long-term archival monitoring frees up time for factory workers to focus instead on productivity, quality and innovations. This hybrid approach reaps significant benefits for factories, employees, their customers and the community.

Real-time analysis helps prevent mishaps and provides context to factory operations to make pertinent decisions on the floor, while the archival analysis helps factory owners make strategic decisions to enhance the layout, machinery, cost savings and overall output efficiency of the business over time. Industry players stay abreast of ever-changing technologies to construct optimal floor environments. And as quality improves and the quantity increases, the working environment becomes more positive, productive and optimal for innovation.

The variety of sensors has multiplied in recent years, enabling granular monitoring of the entire factory.
As senior manager of asset-performance management (APM) product marketing with AspenTech, Robert Golightly knows the importance of machine maintenance and the value in predicting when things will go south. Here he shares his perspective on getting real, reportable results that inform real, preventative actions.

**Smart Industry:** What are the biggest challenges for companies in demonstrating ROI results?

**Robert:** The biggest challenges are threefold.

The first challenge is to clearly identify the objective of the IoT project. Merely having access to IoT technology doesn’t equate to value. Organizations that opt to digitize everything in their path will get a boatload of data, but no clear understanding of how to use that data. That’s why it’s important for organizations to identify, upfront, where their biggest challenges are and digitize only for that—solving for a specific problem. Data is not the answer; it’s what organizations actually do with the data that matters. That’s where they’ll find their ROI.

Secondly, prioritizing areas of impact is a must to demonstrate clear and compelling ROI. The only reason any industrial company embarks on an IoT project is to drive higher levels of operational excellence. Those priorities can be ensuring safer environments, more efficiency, more profitable operations, improved sustainability (energy management, for example) to bridging the talent gap and driving improved organizational excellence. For example, we’ve seen results from real-world applications of prescriptive-maintenance software in the oil-and-gas industry. At a large North American refinery, our prescriptive-maintenance software gave eight weeks advance notice on a compressor failure—a full...
seven weeks before its state-of-the-art vibration system detected the impending breakdown. Prioritizing the area of impact—here, key, costly plant equipment—makes for a clear ROI analysis. The costs of emergency shutdown, loss of available equipment to produce product and unhappy customers (plus the potentially disastrous EH&S implications) will add up significantly compared to the investment in a quickly deployed, low-touch analytics and machine learning prescriptive-maintenance application.

Thirdly, quantifying improvement targets will make or break any ROI exercise. IoT ROI comes from clarifying what you are applying the technology for and then comparing the returns from new, emerging tech to older… those tried-and-true methods. Any solution needs to fit into industrial companies’ workflows and legacy-technology infrastructure. That’s where the ROI becomes most clear, when new tech drives high and sustainable levels of operational excellence.

Smart Industry: In digital transformation, is it possible to avoid “rip and replace” with old equipment or legacy systems?

Robert: Improving operational performance to increase return on assets and manage risk is nearly impossible without connected assets. Here are the challenges: companies encounter connectivity issues in the form of out-of-the-way locations that lack even basic internet services, old equipment not yet sensor-ized, a mash-up of incompatible protocols, OEMs and Programmable Logic Controllers (PLCs). In the industrial world, these are “stranded assets;” up to 40% of industrial assets fall into this category.

Connecting assets, aggregating data and performing advanced analytics delivers the data-driven insights needed to improve performance (as measured by more reliable assets that produce more, break down less and cost less to fix). The IoT has the potential to offer a huge competitive advantage for companies, who can then use those real-time operational insights to make faster and smarter business decisions and reduce operating costs. This is all, in large part, made possible by one phrase that bears repeating: the edge.

The ROI on the IoT comes from driving reliability enterprise-wide without ripping and replacing existing infrastructure—with drop-in edge-computing solutions that can reduce deployment costs by up to 70% and can be implemented in days, not weeks. Connectivity at the edge simplifies IoT applications and seamlessly integrates and interoperates with legacy systems. Analytics at the edge eases the processing strain on the entire network; buffering, data aggregation, data compression and analytics on the edge optimizes and overcomes the connectivity challenges present in oil fields, refineries, mining sites, power facilities and other industrial environments.

To get the best ROI, consider the costs of cellular or satellite networks, as well as the storage costs of the cloud; then investigate edge-connectivity software that supports Windows and LINUX edge devices using standard industrial protocols, such as MQTT, OPC-UA, OPC-DA and Modbus. Working with what you have to make digital transformation work for the business is where ROI and IoT intersect.

Smart Industry: How should organizations approach demonstrating prescriptive-maintenance savings to management/executives?

Robert: The World Economic Forum estimates IoT could contribute $20 trillion to global GDP by 2020. You’ll need more to convince the higher ups that prescriptive maintenance is adding real, measurable value, though.

To project and report savings from prescriptive maintenance, convincingly, to your management, think about the shared operational-excellence goals everyone is trying to achieve. Most IoT applications involve customers trying to solve complex problems that involve
many data variables with intricate relationships that demand the use of big-data tools and large amounts of compute power. There are many applications for AI, multivariate analysis, pattern recognition, event detection and machine learning. Get right to the bottom line instead. How far in advance was the failure detected? These examples below project and report one (or two) compelling numbers that show value.

- In a drilling operation, prescriptive-maintenance software correctly detected calibration errors on drilling-joystick operations that had gone unnoticed. Prescriptive-maintenance software provided two to four weeks’ warning of impending failures on top-drive, mud pump and drawworks components.
- A multinational mining company used prescriptive-maintenance software to significantly improve production uptime with an average time-to-failure of 40 days on a pump. An oil-and-gas company had experienced unexplained breakdowns on numerous compressors.

Prescriptive-maintenance software provided notice seven weeks earlier than the state-of-the-art vibration-analysis system. We heard from one European customer that for most companies, 15% gross margin losses are attributable to unplanned versus prescriptive maintenance. Even best-in-class approaches 4–5% losses.

**Smart Industry:** What is the value-add of prescriptive analytics for organizations?

**Robert:** Prescriptive analytics offer the best way to use reliability for competitive advantage. Nothing hurts asset-intensive businesses more than unplanned downtime. Prescriptive maintenance is one of the best ways companies can apply advanced analytics and machine learning to a clear and present problem. The National Association of Manufacturers suggested worldwide, manufacturing is a $14 trillion year business with a big problem—10% of manufacturing losses are from equipment breakdowns costing $1.4 trillion.
each year. We call our own prescriptive-maintenance software “the Science of Maintenance.” This concept centers around turning traditional maintenance into a data-driven initiative that improves reliability by applying IoT tech to improve operational excellence.

**Smart Industry:** Provide examples of organizations that excelled in showing IIoT ROI?

**Robert:** The Saras oil refinery used AspenTech prescriptive-maintenance software to detect impending failures with 91% accuracy, with 30 days of advance warning. Lower maintenance costs were a benefit—but the biggest value was reliability as a clear driver of operational excellence in the areas of safety, efficiency and profitability.

Specialty-chemicals company Borealis gained longer lead time detection of repeating failures, including 27 days advance notice for central valve failure, transfer learning (‘inoculating’ similar assets with software-defined failure signatures to scale the benefits of prescriptive maintenance enterprise-wide) and the ability to capture fast-moving failures before they caused major damage.

**Smart Industry:** What are some best practices to improving and demonstrating IoT ROI results?

**Robert:** Apply knowledge, not just technology. Capitalizing on the volumes of sensors deployed and data collected is more about the application of technology than the technology itself. Knowledge in the form of data science embedded in software transforms data into tangible and repeatable benefits for customers. The result is sustainable software applications that leverage machine learning, knowledge automation and systems-level thinking to achieve digital transformation and drive operational excellence.

Reliability is an industrial-business-model disruptor that addresses the bottom-line-oriented operational functions of asset and capital-intensive industries. There’s a huge opportunity to deliver greater reliability and greater ROI on IoT via prescriptive-maintenance software to many industries including metals & mining, pulp & paper, power—like the energy and chemicals companies, these verticals all have critical, costly-to-fix equipment that shut down the business when they break. With low-touch prescriptive-maintenance software, getting ROI from the IoT is now within reach.

Reliability is an industrial-business-model disruptor that addresses the bottom-line-oriented operational functions of asset and capital-intensive industries.
Hip HART: Innovative applications of HART technology in the era of IIoT

By Tom Watson, manager of corporate marketing at Moore Industries Worldwide

- The ability to use existing industrial Ethernet and wireless networks in process manufacturing plants and automation facilities has made data exchange easier than ever, enabling a host of capabilities, from predictive maintenance to reduced labor and costs.

Process and diagnostics data from smart HART digital field instruments is being shared with mid and higher-level control, asset management and data information systems without having to upgrade expensive process control systems. At Moore Industries, we are seeing numerous customers using the HES HART to Ethernet Gateway System to collect and transmit valuable smart HART device data to these higher level systems over Ethernet via MODBUS/TCP for predictive analysis and control decision-making.

In a recent application, a customer needed to control two valves which had Siemens smart HART positioners installed and had a further requirement to communicate actual valve position over Ethernet using MODBUS/TCP to their higher-level systems.

Originally the customer wanted to use our model 535 or 545 PID Controllers to control the two valves in order to balance and/or limit each valve’s travel to maintain final pressure through the system, but they realized that the controller’s communication capability did not support Modbus/TCP as their DCS and historian required.

Moreover, the higher-level monitoring systems wanted to monitor and record where actual stem positions currently were, not where the valve controller was driving them to via the 4-20mA signal. This could only be obtained by reading the HART data from the smart positioners.

The HES 4-channel model was utilized to pick up the actual stem position HART data from the smart positioners and send it to the higher-level systems—no longer requiring the valve controller to communicate the CV (Controlled Variable), or desired stem position, output. The HES was an effective and economical solution that enabled the customer to take advantage of existing HART data from the positioners and share that critical data with their higher-level systems on their existing Ethernet infrastructure.

The ability to use existing industrial Ethernet and wireless networks in process manufacturing plants and automation facilities has made data exchange easier than ever.
The human-powered factory of the future

By Lawrence Whittle, CEO of Parsable

Much of the talk about digital transformation and Industry 4.0 trends quickly toward plants that are “lights out” as a result of automation.

The fact is, manufacturers who simply digitize existing processes by replacing human workers with sensors and robots are missing out on the heart of Industry 4.0—the opportunity to remake your processes so that they’re not just digital, but better in every way. It’s about augmenting humans and machines.

The consumer-products factory of the future is more than just sensors and robotics. Far from being a dark future, it is ablaze with machine-assisted human intelligence driving unprecedented process improvements and product innovations.

As we think about what the factory of the future looks like over the next decade, what steps can we take now to achieve that vision, one that enables companies to develop new products, grow revenue and engage with consumers in a completely new way?

IN 2029: PRODUCTION DELAYS AND LINE SHUTDOWNS LARGELY A THING OF THE PAST

You’d think that with machines in a production line far more complex than a decade ago, and automation that has increased the overall complexity and vulnerability of the line, there are more things to go wrong.

One reason is that problems-in-the-making are routinely spotted and avoided. Predictive analytics continuously comb through the data streaming in from the IIoT, including from machine sensors and human actions. These systems spot outliers from norms—a blending machine whose top speed is gradually slowing, a worker putting too little time into a particular cleaning step—and
predict likely outcomes. Prescriptive analytics identify preventive actions and trigger alerts, actions and suggestions via mobile to workers, supervisors and/or maintenance teams.

What to do now: As you simultaneously improve and automate your production processes, you capture more and more data from sensors, machines and human work. Combine this data to create the full picture of what’s happening in the plant or factory. It may be easier said than done, but the growing popularity of open APIs—which can connect a myriad of machines and mobile devices to cloud platforms, graph databases and data historians that store and analyze relationships between data from different sources—will surely help.

With this full picture of what’s happening in the plant or factory. It may be easier said than done, but the growing popularity of open APIs—which can connect a myriad of machines and mobile devices to cloud platforms, graph databases and data historians that store and analyze relationships between data from different sources—will surely help.

With this full picture, manufacturing-excellence programs can drive improvement faster. Companies can also create accurate digital twins to compare existing processes with proposed alternatives and measure simulated results before actually making real-life changes.

IN 2029: SKU EXPLOSION IS JUST THE STATE OF PLAY
The manufacturing unit-of-1 is coming. The multiplication of SKUs is no longer a problem, and the consumer desire for endless choice is a given. Debate about the wisdom of chasing the “longtail” of demand has evaporated, since the longtail now accounts for an increasing share of every manufacturer’s growth and margin.

Line changeovers aren’t considered disruptions to production; they’re seen as its very essence. And a prediction made by PwC in 2015 has come true: “The ability to handle product line complexity cost-effectively can, in itself, become a competitive advantage.”

What to do now: Simplifying the execution of complex work is key to successfully supporting long-term SKU expansion, and right now much of that work is still being done by humans. So, let’s empower them.

Leverage technology that breaks down complicated procedures into clear steps for your workers and enables them to better collaborate, both side-by-side and top to bottom. This is one of the most important early steps you can take toward the consumer-products factory of the future, one that many consider as the foundation of Industry 4.0.

IN 2029: MACHINES + HUMANS = INNOVATION
Machine learning does what it does best—rapidly sorting, classifying and examining relationships between different types of data. With the results of this data-crunching presented in a handful of relevant statistical or visual clues, humans then do what they do best—rapidly reason their way through a problem to a solution.

In 2029, manufacturers recognize that while predictive diagnostic analytics are helpful at pointing in the right direction, humans have an unmatched field-of-vision for complex troubleshooting. Human brains can consider both digital and analog information, follow hunches, and weigh inputs and tradeoffs to hone in on the root cause of problems and develop the best remedy.

What to do now: If you try to fully automate your production processes without having measured and analyzed the human-labor component, you’ll have a huge blind spot. What you can’t see may cause you to approach digitization in suboptimal ways. You might even automate broken processes without realizing you had the opportunity to fix them through digital transformation.

As you establish and refine your long-term digital-transformation vision, don’t forget about the uniquely human aspect of work, which enables a clearer view of the starting point for your journey to the consumer-products factory of the future. You’ll be able to see where straight automation is the way to go. You’ll know where human workers play essential roles.

And you’ll understand how to use technology to support their work and augment their capabilities.
Accelerate Your HART Data at the Speed of Ethernet

Get the process detail you need from your Smart HART devices to MODBUS/TCP and HART-IP based monitoring and control systems at the speed of Ethernet with the HES HART to Ethernet Gateway System.

Connect up to 64 Smart HART devices and collect the Dynamic and Device Variables, along with diagnostics, from each device that delivers critical information needed to address process and device problems before they turn into unplanned downtime. Plus, the built-in web server lets you easily monitor all HART device data via any web browser.

To learn more about the Moore Industries HES HART to Ethernet Gateway System
Call 800-999-2900
or visit www.miinet.com/HES