Continuously improve manufacturing process control with visual data science

A current trend in manufacturing is towards tailor-made products in smaller lots with shorter delivery times. This change may lead to frequent production modifications, resulting in increased machine downtime, higher production costs, and the need to rework or scrap faulty products produced by processes that are unstable or not optimized.

To satisfy the customer demand behind this trend, manufacturers are moving quickly to new production models with a lower lead time but without compromising quality. Therefore, quality assurance and process control are critical areas that IT must support.

At the same time, product traceability becomes central to compliance and quality. Traceability can be achieved by interconnecting data sources across the factory, breaking down multiple data sources, analyzing historical and real-time data for insights, and taking immediate action to control the entire end-to-end process. Doing so can lead to noticeable cost reductions and gains in efficiency, process reliability, and speed of new product delivery. Additionally, data science helps manufacturers find the best setups for machinery.

The smart factory

When transforming into a smart factory, you will aggregate, analyze, and act on all your data. Sensors, equipment, people, applications, and processes are part of a connected ecosystem, providing:.

- Increased uptime, reduced downtime
- Minimized waste and defects
- Higher yields
- Reduced cost due to better quality
- Fewer deviations and reduced non-conformance
- Energy efficiencies
- Traceability and transparency in the manufacturing process

Modern manufacturing operations are highly complex, and industrial control systems must be able to manage in-flight processes within precise limits responsible for delivering efficient, productive, reliable, and safe operations. However, these operations generate a lot of data, often not analyzed, exposing manufacturing processes, operations, and production to risk. Manufacturing CIOs can leverage visual

data science tools that empower manufacturers to improve decision-making and act on insights.

A couple of high-value use cases are described in the section below.

Process optimization

With process optimization, manufacturers can identify bottlenecks in production, expensive quality problems, excessive energy consumption, and failure points. Process optimization analyzes historical data to detect opportunities for time, cost, and quality improvement. It may also include identifying suppliers and materials that do not matter to final product quality, resulting in more significant savings.

Proactive process monitoring

Traditional process monitoring focuses on parameters one at a time, using quality control charting to monitor key metrics, detect deviations from the baseline, and generate automated alerts or actions. This methodology allows manufacturers to verify that parameters are "in control" and consistent with design specs. With today's complex processes and products, manufacturers may need multivariate methods such as Principle Component Analysis to detect more subtle anomalies that degrade product quality and reliability. Visual data science solutions have enhanced Six Sigma practices to improve businesses' efficiency and competitiveness.

Process digital twins

Advanced process control is a form of digital twin technology that involves the use of sensor and metrology data to implement real-time tuning and control of processes. These solutions involve a digital twin that predicts the output of a process, while still in flight, and adjusts the process recipe, in real time, to hit the desired target. This facilitates greater control of process variability than is achieved with the after-the-fact process control techniques above.

Better quality, more loyal customers, higher margins

Manufacturers achieve robust quality when the variability of raw materials, ambient weather, supplier variability, or fuels do not affect the quality of the final product. For example, a car must perform reliably and without variation, even in extreme road and weather conditions. Additionally, this car must perform well despite any uncontrollable variability in supplier part quality, raw materials, or other manufacturing conditions.

Next-generation process control capabilities

Using the methods and technologies above, every manufacturer can implement smart factory practices: root cause analysis, operations monitoring, process control, and predictive maintenance to boost overall equipment effectiveness (OEE). With real-time analytics, data science, and AI-driven visualizations, industry-specific analytics platforms are available, allowing every manufacturer to develop future-ready strategies, and capitalize on opportunities.

Root cause analysis

The first phase of a manufacturing program is to identify the root cause of product quality problems. Manufacturers may analyze simple linear correlations between end product quality measurements (yield, defects, and returns) and upstream product, process, equipment, component, material, or environmental measurements. They can perform analysis of variance (ANOVA) equipment studies to identify the individual process steps and factors (machine, recipe, operator, and others) that produce a bad product. Similarly, manufacturers can identify component commonality analysis to identify outsourced component sources and process factors responsible for the faulty product.

After identifying the most evident causes of product-quality problems, manufacturers may have additional problems that are more difficult to diagnose. Oftentimes, these are due to complex non-linear effects and interactions between predictors not detectable with the techniques used during the first phase of analysis. Gradient Boosting Machine (GBM) modeling, a machine learning algorithm, can help uncover these complex relationships to solve the next phase of quality problems—and by using GBM from the beginning, combining both quality improvement phases to accelerate the ramp-up to mature production can become possible.

Predictive maintenance

Predictive maintenance involves gathering targeted data for AI-driven analysis, which will help anticipate potential failures and increase OEE. Prescriptive actions can be triggered based on predictions and make multiple recommendations to plant supervisors. Companies can then schedule maintenance at times with minimal impact on operations, avoiding unexpected equipment and product waste downtime.

Operation monitoring

Having end-to-end visibility of data helps manufacturers get insights from control charts for early warning systems that monitor:

- Key performance indicators
- Deviations from baseline
- Process control raises
- Automated alerts

Knowing if manufacturing processes are in a state of control is critical to minimizing production costs.

Process control solution

- Delivers fit-for-purpose processes that support product quality and uniformity
- Reduces major accident hazard (MAH) exposure, near misses, as well as health, safety, and environmental (HSE) risks
- Supports asset integrity
- Improves environmental, social, and corporate governance (ESG) and sustainability reporting—decreasing waste, emissions, and resource usage
- Maximizes profit and efficiency while reducing working capital
- Increases productivity and reduces cycle time
- Identifies the best equipment configuration parameters
- Measures reliability and process capability (CPK)
- Delivers predefined data models to build a single source of information

Advanced and historical analysis

Visual data science capabilities are a perfect complement to traditional analytics. ML algorithms can uncover the hidden relationships between manufacturing variables, product yields, and quality even if traditional data correlation doesn't find strong signals. Manufacturers have successfully implemented GBM models with a data function that uses the R generalized boosted regression model package. Data scientists have created a reusable industry-specific template that accepts categorical and continuous data for predictors and responses. Analysts can use the manufacturing templates without special knowledge of statistics or machine learning.

Spotfire software has out-of-the-box operations monitoring and process control. It supports Shewhart charts, also known as control or process behavior charts, used to determine if a manufacturing process is in a state of control. Our solution for manufacturers also supports continuous process verification (CPV), shelf-life analysis, and 21 CFR Part 11 used in the pharmaceutical industry for government-regulated manufacturing.

Harness the power of data with Spotfire® for Manufacturing

Spotfire® software enables engineers, factory operators, and facilities managers to apply the latest techniques in data analysis to find anomalies, perform predictive maintenance, monitor quality, and determine root cause analysis to optimize output and ensure maximum yield.

Spotfire for Manufacturing blends visual data science, analytics, and industry-specific capabilities needed by manufacturers—such as artificial intelligence, domain-specific visualizations, and data connectors. It's no wonder Spotfire is trusted by 8 out of the 10 largest high-tech manufacturing firms in the world.

Build your smart factory with Spotfire® for Manufacturing

Help your smart factory get smarter with Spotfire visual data science. Join other leading companies that are already utilizing manufacturing advanced analytics to reduce costs, manage operations, and translate data into insights that matter.

For the next steps of your journey, please visit our website.

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Spotfire® goes beyond basic rearview dashboards to offer a single visual analytics platform for data exploration and real-time decisions. Backed by point-and-click, no-code data science, Spotfire allows even the non-developer to analyze both data-at-rest and data-in-motion, together, for faster time-to-insight and better business outcomes.

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