CRAVE Industry – Operational Digital Twin

Keywords

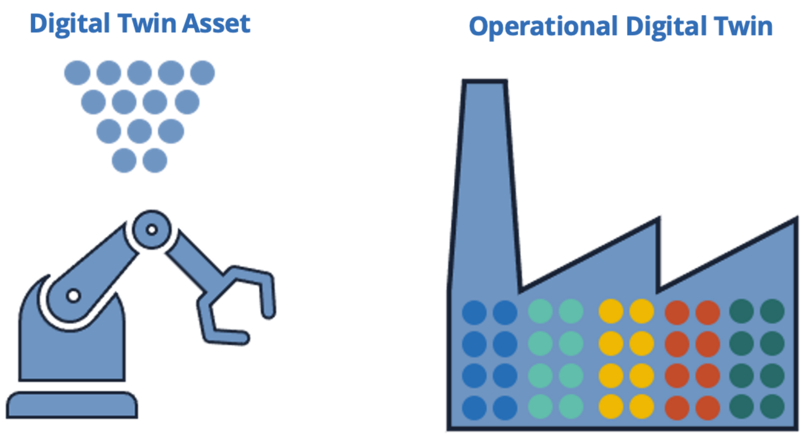
Operational Intelligence, Digital Twin, IIoT, Big Data in Manufacturing, Predictive Analytics, Prescriptive Analytics, Shop Floor Analytics, Digital Manufacturing

Summary

A digital twin is a dynamic virtual representation of a physical asset, product, process, or system. It digitally models the properties, conditions, and attributes of its real-world counterpart. The digital twin allows for the analysis of empirical data captured in real time, including predictive analytics for maintenance and prescriptive analytics for operational intelligence.
Using data from various sources, a digital twin continuously learns and updates to represent the current working condition of the object or process. Decision-makers gain deep insights that are used to improve and optimize the performance of the modeled asset and the larger systems with which it interacts.

Asset Digital Twins vs. Operational Digital Twins

By organizing, cleaning, and analyzing data from a physical asset, you can learn a lot about what has happened, what is happening now, and what might happen next with that equipment. But digital twins can serve a broader purpose than just monitoring devices alone.



What is the best way to use a digital twin to understand machine operations and manufacturing? How can we expand the scope of digital twins to create the maximum possible value?

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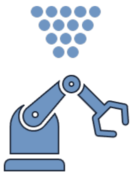
Generally speaking, there are two approaches. Asset digital twins emphasize the idea of a digital twin precisely representing a physical device. These are

vendor-specific models of a single asset or machine, using operational data for asset optimization purposes.



They can be used to:

- Improve performance and reduce operating costs
- Field management of many similar assets, such as engines or robots
- Predictive maintenance

While these types of Digital Twins provide insights into machines and equipment, they do not offer visibility into the complex and important relationship between machines, workflows, parts, products, and batches. The absence of these fundamental insights prevents manufacturing data analysis from providing more than a fraction of its potential impact on production. This limitation has only recently been overcome through an innovative breakthrough in digital twin technology.

Operational Digital Twins also consider the importance of accurately representing a physical device; however, simply representing a physical asset limits the digital twin model's scope and commercial value return. To reach the full potential of digital twins, this second approach considers that these isolated assets must also be viewed as a system. This is the concept of the system-specific digital twin.

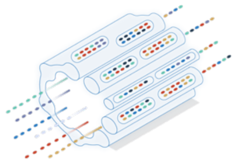
An Operational Digital Twin is a far-reaching innovation that expands the concept of digital twins to provide an integrated understanding of production as a whole. An operational digital twin combines and correlates real-time streaming IIoT data with other information. It then applies machine learning, AI, and advanced modeling techniques to create a dynamic virtual representation of the entire plant. In this way, manufacturers gain full visibility into the multiple, multi-layered interdependencies between assets, processes, and operations.

These unprecedented insights reveal the full commercial value of manufacturing analysis, enabling:

- Scalability to meet the entire range of production opportunities and use cases
- Actionable intelligence to significantly reduce downtime, drastically improve factory productivity and efficiency, and prevent issues before they occur

Operational digital twins are extremely complex and challenging to create and refine. Unlike Asset Digital Twins, they require combining thousands of data sources that come in numerous formats, including real-time streaming data. The only way to ingest, correlate, and integrate such diverse datasets at scale is with AI and machine learning — techniques that have only recently reached the right level of maturity to meet the need.

Based on our experience, a digital twin that is merely a mirror of a single physical asset is insufficient. To derive full value, a digital twin must be a real-time representation of all assets working together on a manufacturing line or in a supply chain. With this approach, a company will have a cascading hierarchy of digital twins tracking other digital twins, allowing for a broad view and the ability to zoom in on an individual part or asset.



This range of possibilities presents opportunities for companies to adopt the broader and more useful concept of the digital twin and is the only way to truly build a foundation for scalable Digital Manufacturing. But, to do this, a company must implement digital twins based on a standardized set of data model.

The Basis for the Operational Digital Twin: Common Data Models per Production Unit

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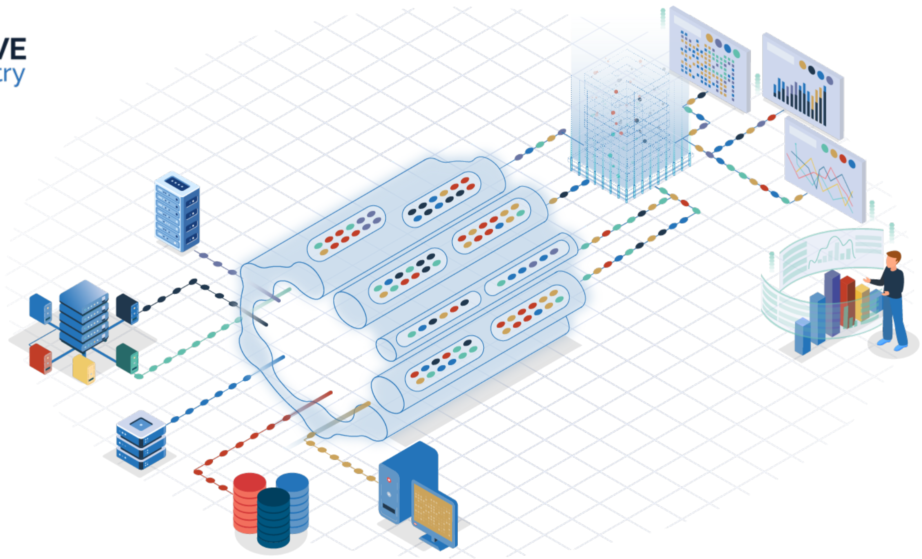
Let's say we are trying to understand vehicle production. A car has 30,000 parts, and if we are to build data models for all the parts being manufactured, we will also have to model tens of thousands of machines. There is no way all these models can be organized and understood — but that doesn't stop companies from trying. Machines have often been the preferred building block, but this is obviously problematic. Crave Industry uses only about ten common data models. One of the most important is the Base Unit Model, which allows clients to continuously understand production activity at different levels: machines, lines, and factories. But effective modeling should not begin with machines, as seen in traditional industry approaches; it starts by modeling production units.

Think of all those machines needed to make a car. A production unit could be the repetitive act of casting an engine block, applying paint or coating, or injecting plastic into a mold for a panel part. It can represent the product realized in either a discrete process or continuous production and can take a second or hours. The types of products are limitless, but the idea of a product unit is common, almost elementary. A product unit is just the repeated cycle of activity by a machine.

From there, the input of the product unit is converted into common data models that allow real-time insights into machines, lines, factories, enterprises, and supply chains.

How Do Common Data Models Organize Data?

Each time a machine executes a product unit, a line of information is generated from all the data associated with that product. The product unit is described with sensor data from machines, quality systems, manufacturing execution systems (MES), historians, enterprise resource planning (ERP), and even environmental data such as temperature and humidity or other data about raw material characteristics.



There is no minimum or maximum data level required to characterize a product unit. The information about the product unit can be flexible with the level of data captured. In terms of a data table, the line of information can be modified to add parameters in new columns as new data becomes available. The information about the product unit also changes as data sources change or delayed or missing data is incorporated. This type of flexible recalculation, impossible until the advent of robust stream processing tools, is essential for factory data.

Once you have a common data model built on product units, it becomes simpler to apply the various types of analytical techniques that engineers and data scientists know well: both at Crave Industry, which has advanced analytical and visualization layers, and with other products, tools, and internal systems.

With access to multidimensional information in real-time, teams can go beyond analysis. They can move, for example, to much more active process management, where experimentation and validation become feasible at previously unimaginable speeds. Teams can also use information derived from product units to manage maintenance or capital investment and combine production data to gain supply chain insights. These and other initiatives become feasible when teams have access to contextualized information that consistently represents all manufacturing processes.

Use Cases for Operational Digital Twin

Visibility	Productivity	Quality	Sustainability
Access critical shop-floor information anytime, anywhere	Perform continuous process improvement	Discover root-causes	Reduce waste
Measure and compare OEE, KPIs across machines, lines and factories	Predict process out-of-control and equipment failures	Reduce scrap	Optimize raw materials consumption
Measure quality performance	Monitor and track production, Ids, Birth Dates and regulatory dimensions	Compare and analyze quality indicators across plants	Reduce energy consumption
Control process with strict tolerances	Increase production capacity	Setup alerts to ensure a consistent process	Reduce CO2 emission

Conclusion

As companies advance to the next generation of manufacturing, future factories must be equipped to tackle the performance challenges of a new era of operational excellence. Operational intelligence will become mandatory for manufacturers to compete in global markets and extended supply chains. Actionable insights derived from both real-time operational production processes and historical production will provide the lifeblood to optimize manufacturing processes and determine and establish best practices going forward.

Today's operational analytics applications for manufacturing can collect Big Data through this production process and use predictive and prescriptive analytics engines that employ machine learning, multivariable statistics, and rule-based logic to empirically reveal the origins of even the most complex problems and suggest decision options to resolve them.

To discover and analyze the information contained in the vast reservoir of manufacturing data, Big Data will be key to the digital factory of the future.

The Crave Platform is a system specifically developed to create Operational Digital Twins. It uses AI to automate the process of digitally representing any manufacturing machine, line, plant, supplier, part, or batch.

The data pipeline integrates algorithms, learning from specialized systems, and advanced techniques to continuously ingest, transform, and combine streaming data from thousands of sources and assets.

The result is a digital twin that provides deep actionable insights across all layers of the manufacturing environment, from individual sensors to entire supply chains.

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