Methods

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MOUSER ELECTRONICS

Welcome from the Editor

When you think about engineering in the context of Industrial Revolution, do you think of innovations and advancements that previous generations made possible, or do you think of the innovations and advancements yet to come? Perhaps both?

"At the tail end of Industry 3.0, we find ourselves a bit whiplashed from the seemingly rapid-fire advances of recent years. We find ourselves connected to everybody and every "thing".... Yet we also find ourselves not truly integrated with the physical and cyber systems around us."

Indeed, engineering innovations belong to eras defined by advancements. In the First Industrial Revolution, engineers harnessed water and steam to advance mechanical production. In the Second Industrial Revolution, engineers harnessed electricity to further advance efficiency in manufacturing and distribution. In the Third, engineers brought information technology to the forefront, connecting resources, companies, and people via the Internet, with technologies, business systems, and manufacturing outgrowths that have taken on lives of their own.

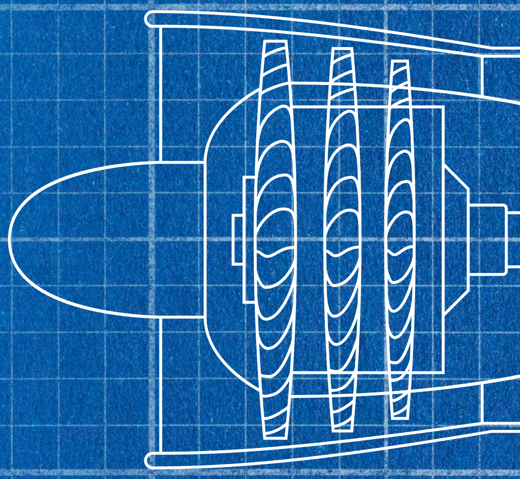
At the tail end of Industry 3.0, we find ourselves a bit whiplashed from the seemingly rapid-fire advances of recent years. We find ourselves connected to everybody and every "thing" through the Internet, mobile devices, and the smart infrastructure around us. Yet we also find ourselves not truly integrated with the physical and cyber systems around us. As a result, we cannot see the larger picture, are limited in the problems we can solve, and are engineering in relative isolation.

Before we even catch our breath, Industry 4.0 has already begun and has firmly claimed its own identity, purpose, and scope: To combine the physical systems of the early revolutions with the cyber systems of the recent revolution with the people, companies, and industries that have come to rely on them. An era of integrative engineering is upon us. One engineering technique already in use holds tremendous promise in helping us meet these goals. Digital Twinning maps physical assets to a digital platform that can analyze components, products, systems, and processes; provide real-time feedback as to efficiency, health, environmental conditions, maintenance needs, and more; and as a result, enable engineers to create smarter, more efficient, more reliable, more maintainable products, systems, and processes.

In 2018, we are privileged to have the physical and cyber systems that came before us and to be an integral part of shaping Industry 4.0. Mouser Electronics is pleased to be on the leading edge supporting the proliferation of digital twinning as a significant part of the revolution ahead. In this issue of *Methods*, we hear from one of the world's foremost experts on digital twinning; discuss the technology landscape and types of twinning; reveal the many potential benefits; describe the role of sensors, edge-nodes, and communications; and present security and end-user privacy implications and solutions. We also present an interesting paradox of digital twins: They require more sensors and related hardware, yet simultaneously help engineers solve component selection challenges.

As we bring Industry 3.0 to a close and embark on Industry 4.0, we take pause: To acknowledge the engineering innovation that came before us, to fathom the unique juncture we're at, and to marvel at the possibilities to come—the possibilities we will create.

Deborah S. Ray
Executive Editor

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change everything about design, construction, operations, and maintenance of complex systems. In this context, the Internet of Things (IoT) would be the lifeblood, separating traditional models from next generation DTs.

Advances in Companion Technologies

At the heart of digital twinning is a key concept: The virtual and the physical are inextricably linked. Thus, IoT and the more manufacturing-focused Industrial Internet of Things (IIoT) have become key enablers that allow data to flow between the digital and physical twins. Embedded sensors on a physical object can monitor all aspects of the object's operations as well as the operating environment. This valuable data will feed to the object's DT via IoT for operators and engineers to understand better how a system is operating in real-world conditions.

Reliably enabling a system's teleoperation requires near ubiquitous Internet access. The forthcoming rollout of fifth generation wireless networks, or 5G, will bring many advantages to the wireless market that will be necessary for further proliferation of IoT and IIoT. The advantages include increased reliability, more concurrent users, and greater built-in support for device-to-device communications. A parallel development, multi-access edge computing (MEC), will help ensure network throughput by offloading cloud processing and maintaining it closer to the sensor nodes, which are foundational to IoT. In short, the processing horsepower packed into today's inexpensive embedded systems eliminates the need for raw data transport across networks (and/or the Internet) to activate processing by high-powered servers.

The Digital Thread

A fully effective DT needs a closed data loop, or digital thread, that flows from conceptual design all the way to real-world feedback from fielded systems. Embedded electronic products require multiple disciplines to come together to design and manufacture a finished product. Computer-aided design/engineering (CAD/CAE) software suites enable designers and engineers to build the enclosure and mechanical aspects of a product. Electronic design automation (EDA) applications enable schematic capture and circuit board layouts. Computer-aided manufacturing (CAM) software translates the designs into instructions that manufacturing machinery understands to turn the digital into the physical. Each step along the process adds more data to the DT.

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The digital thread is the connective tissue that enables the otherwise disparate applications to communicate. Permitting disparate software applications to interoperate, an emerging class of software known as robotic process automation (RPA) enables easily built digital threads. Running at a human user interface (UI) level, RPAs empower disparate applications to interoperate, without expensive software rewrites for each individual application. This capability will prove to be very useful as the digital thread continues to collect data and provide information to the DT from various business systems, such as customer relationship management and supply chain applications. Even after a product has been sold and is in use, the digital thread continues to feed telemetry data to the manufacturer for model refinements on the basis of how a product is actually performing in real-world conditions.

Machine Learning Turns Data into Information

All the data moving along the digital thread are impossible for humans to efficiently process on their own. Machine learning technology will be essential to sift through the mountains of data that feed back from fielded systems. Finding anomalies or trends will allow engineers and designers to refine future product iterations in a more predictive fashion than possible today. Cognitive digital twins, powered by AI technology, will allow products to improve over time without any human intervention. In short, instead of just performing mathematical analyses on raw data, a cognitive digital twin would be able to learn, reason, adapt its logic, and make informed decisions on its own. The result: The ultimate in technology self-help! The implications of a more cost-effective, rapid adaptation and an increasingly intelligent product development lifecycle would seem to make any investment in this technology well worth it.

Conclusion

With DTs, every physical product can have a virtual counterpart that can perfectly mimic the physical attributes and dynamic performance of its physical twin. DTs are quickly becoming a feasible reality for many companies looking to make better products and more informed business decisions. Rooted in modeling and simulation, DT has gained traction due to advances in companion technologies, like wireless communications, sensors, AI, machine learning, and more. Digital twinning may indeed shift the landscape of engineering design as we know it.

Digital Twins vs. Simulations

A false assumption suggests that DTs are just another type of modeling and simulation. If this were the case, DTs wouldn't be useful for electronics engineers. Electronic design automation (EDA) software, which enables circuit capture and simulation, has been around for decades. However, "twin" is the emphasis here. It implies the existence is a physical duplicate: of course, under the consideration that the product doesn't solely live as 1s and 0s in a computer. For product developers who choose to embrace DTs in their design process, this means physical prototypes become even more important. Simulations are only as good as the assumptions a person makes who is running the simulation. However, DTs rely on aggregated real-time feedback from all prototypes being used in various real-world settings. This differentiating philosophy has significant implications for hardware designers.

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