MIT Technology Review Insights

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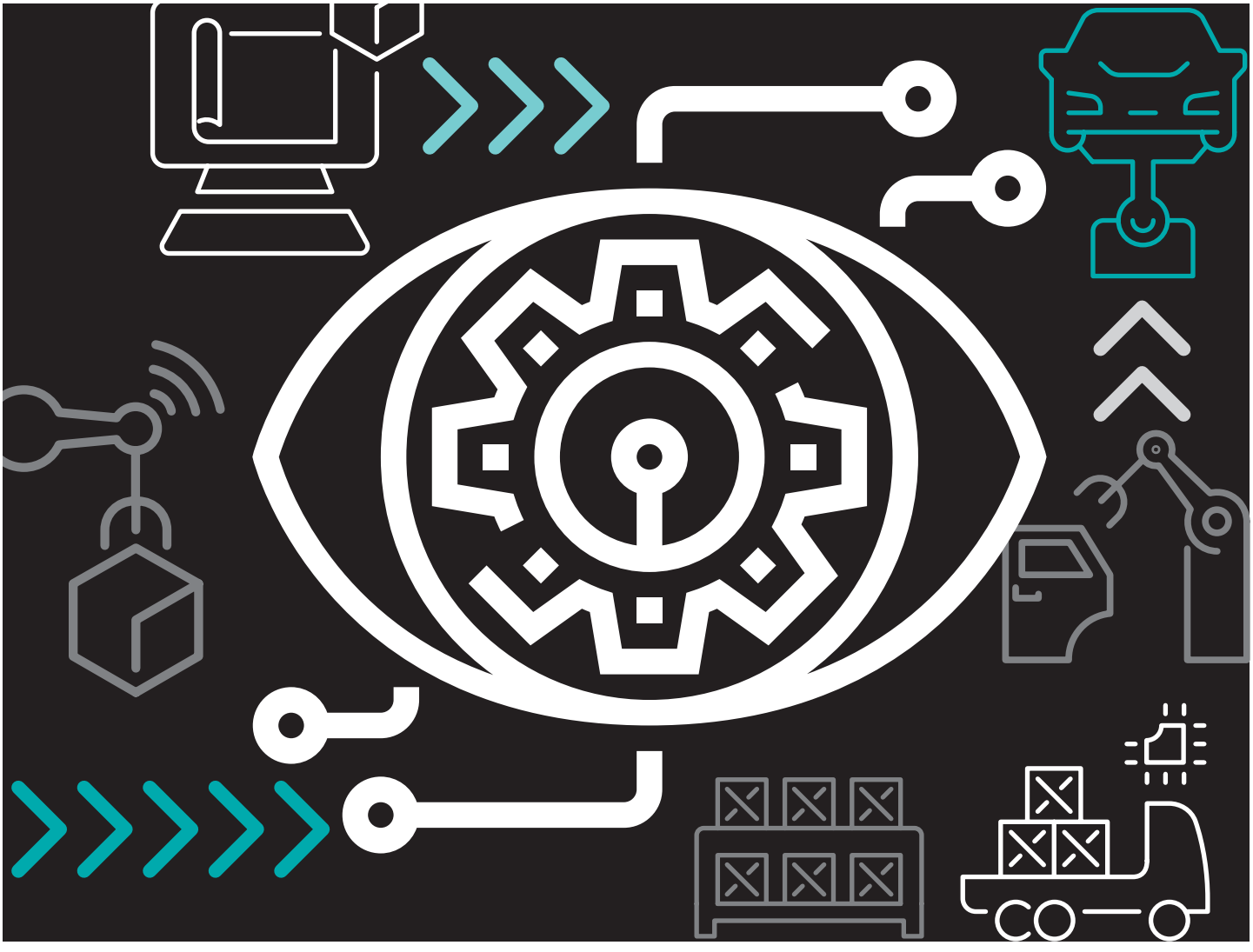
With artificial intelligence, simulation software makes engineers' jobs easier, improves production processes, and spurs innovation.

Product design gets an AI makeover



Engineers are under unprecedented pressure to build products that are used by thousands, if not millions, of consumers every day.

Just ask Bernd Zapf. Head of development, new business, and technologies at Heller Group, a machine tool manufacturer in Germany, Zapf says today's organizations must increasingly "strike a balance between the design, engineering, manufacturing, operation, and craftsmanship of developing a product based on stringent guidelines."

It's a tall order, but one that Zapf says artificial intelligence (AI) technology can support by capturing the right data and guiding engineers through product design and development.

No wonder a November 2020 McKinsey survey reveals that more than half of organizations have adopted AI in at least one function, and 22% of respondents report at least 5% of their companywide earnings are attributable to AI. And in manufacturing, 71% of respondents have seen a 5% or more increase in revenue with AI adoption.

"AI is a promising and exploratory area that can significantly improve user experience for designing engineers, as well as gather relevant data in the development process for specific applications," says Katrien Wyckaert, director of industry solutions for Siemens Industry Software.

Key takeaways

1. Manufacturers are relying on the data-dicing power of artificial intelligence (AI) to accelerate and enhance product development, helping engineers cut through complexity and quickly design and build better products.

2. AI can streamline the processes behind the most sophisticated machinery and systems, getting products to market faster and driving product innovation. AI can also help manufacturers prevent unnecessary machine downtime by running predictive maintenance – that is, using data about equipment to detect signs that indicate emerging performance issues.

3. Just as AI guides human engineers in the product development process, engineers are needed to determine how AI can help. Together, AI and human ingenuity can be packaged into a manufacturer's systems and processes to offer vast stores of knowledge to subsequent generations of engineers.

But that wasn't always the case. Once "rarely used in product development," AI has experienced an evolution over the past few years, Zapf says. Today, tech giants known for their innovations in AI, such as Google, IBM, and Amazon, "have set new standards for the use of AI in other processes," such as engineering.

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Katrien Wyckaert, Director, Industry Solutions, Siemens Industry Software

The result is a growing appreciation for a technology that promises to simplify complex systems, get products to market faster, and drive product innovation.

Simplifying complex systems

A perfect example of AI's power to overhaul product development is Renault. In response to increasing consumer demand, the French automaker is equipping a growing number of new vehicle models with an automated manual transmission (AMT) – a system that behaves like an automatic transmission but allows drivers to shift gears electronically using a push-button command.

AMTs are popular among consumers, but designing them can present formidable challenges. An AMT's performance depends on the operation of three distinct subsystems: an electro-mechanical actuator that shifts the gears, electronic sensors that monitor vehicle status, and software embedded in the transmission control unit, which controls the engine. Because of this complexity, it can take up to a year of extensive trial and error to define the system's functional requirements, design the actuator mechanics, develop the necessary software, and validate the overall system.

In an effort to streamline its AMT development process, Renault turned to Simcenter Amesim software from Siemens Digital Industries Software. The simulation technology relies on artificial neural networks, AI "learning" systems loosely modeled on the human brain. Engineers simply drag, drop, and connect icons to graphically create a model. When displayed on a screen as a sketch, the model illustrates the relationship between all the various elements of an AMT system. In turn, engineers can predict the behavior and performance of the AMT and make any necessary refinements early in the development cycle, avoiding late-stage problems and delays. In fact, by using a virtual engine and transmissions as stand-ins while developing hardware, Renault has managed to cut its AMT development time almost in half.

Speed without sacrificing quality

So, too, are emerging environmental standards prompting Renault to rely more heavily on AI. To comply with emerging carbon dioxide emissions standards, Renault has been working on the design and development of hybrid vehicles. But hybrid engines are far more complex to develop than those found in vehicles with a single energy source, such as a conventional car. That's because hybrid engines require engineers to perform complex feats like balancing the power required from multiple energy sources, choosing from a multitude of architectures, and examining the impact of transmissions and cooling systems on a vehicle's energy performance.

"To meet new environmental standards for a hybrid engine, we must completely rethink the architecture of gasoline engines," says Vincent Talon, head of simulation at Renault. The problem, he adds, is that carefully examining "the dozens of different actuators that can influence the final results of fuel consumption and pollutant emissions" is a lengthy and complex process, made by more difficult by rigid timelines.

"Today, we clearly don't have the time to painstakingly evaluate various hybrid powertrain architectures," says Talon. "Rather, we needed to use an advanced methodology to manage this new complexity."

Automaker Renault is using AI to untangle the complexity of developing automated manual transmission, which allows drivers to shift gears using a push-button command.

The answer: GREEN (Global and Rational Energy EfficieNcy). Developed with the help of Siemens Digital Industries Software and connected to Simcenter Amesim software, GREEN is a simulation platform that lets engineers quickly parameterize models, run simulations, and process results so that, time after time, they select the most efficient hybrid architecture possible.

Talon says the easy-to-use, collaborative simulation platform not only simplifies work processes for Renault's system engineers but "significantly reduces time to market while improving quality."

Early detection for fast action

But reducing complexity and getting products to market faster aren't the only reasons AI technologies are gaining traction among engineers. Constant availability of machinery is critical to plant productivity. Fortunately, AI is already helping organizations prevent unnecessary downtime – and costs – by collecting data from running machines in the factory and using it to train AI models for predictive maintenance.

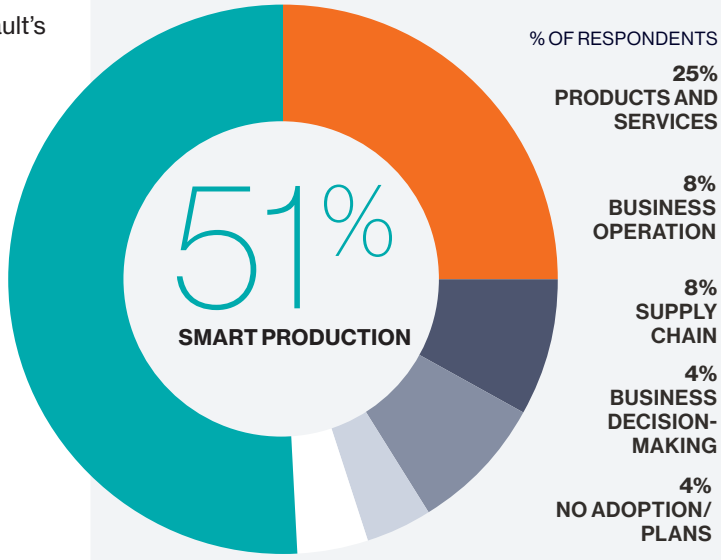
These models can detect signs that maintenance is needed, such as fluctuations in vibration signals, which might indicate an emerging issue. From there, factory workers can schedule a maintenance session when it makes most financial sense, such as on a Saturday, so there is no loss of production. What's more, by proactively performing maintenance, organizations eliminate the need to wait for the delivery of replacement parts from other countries – a time-consuming and costly process.

Zapf recognizes the long-term value of predictive maintenance. "Not only is it very complicated for operations people to identify the real problem in a machine, but if there is an interruption, you can't produce any parts," he says. To prevent such an occurrence, Heller relies on AI-powered technology from Siemens to "monitor the condition of our machines and predict at what time in the future they will likely break down. This prevents unanticipated interruptions in the machines, which allows us to increase production time without adding any hardware."

Audi is another automobile manufacturer reaping the benefits of predictive maintenance. In the past, many manufacturers relied on manual processes to predict

Key areas for AI adoption

Smart production, or automating factory processes, is the most popular AI application for manufacturers, with product development coming in second.



Source: Deloitte's "AI Enablement on the Way to Smart Manufacturing," based on a survey of 110 large and midsize companies from the top 500 Chinese manufacturing companies

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Vincent Talon, Head of Simulation, Renault

the quality of plant equipment and flag potential problem areas. “But that was inefficient in energy, time, and human power,” says Martin Biller, a data scientist at Audi. Part of the problem, he says, is “manual quality checks are often focused on only a small subsample of equipment, which may not have been representative of all the other spots.”

Today, Audi relies on Siemens’ SIPLUS Condition Monitoring Systems (CMS) to continually monitor the production process for signs of potential damage to the drivetrain – the group of parts that deliver power to the wheels – or its components.

SIPLUS CMS works by recording and analyzing mechanical variables from the machines. If an anomaly is detected, an alarm-signaling function sends a message to a higher-level control system long before any actual damage can occur. In turn, service personnel can incorporate the repair of the damage into the normal maintenance cycle, thereby significantly increasing the availability of the press lines. The system also provides recommended action plans, enabling workers to make the right decisions, such as estimating how much longer secure operation is possible based on the measured variables over time.

Analyzing the vast volume of data generated by a digital factory can be challenging, though. To streamline the process, SIPLUS CMS works with MindSphere, the as-a-service offering from Siemens, specifically designed to analyze large quantities of data. Eventually, Biller says, “our goal is to not only use AI-powered quality checks in one specific factory, but to develop AI use cases and scale them across the whole company” for greater standardization and productivity. He adds, “If you have the same architecture in Brazil, for example, you can easily transport these AI algorithms.”

Precision in processes

Another product design advantage of AI: improved process quality. When using large machine tools, individual drills or milling tools need to be transported from the magazine to the spindle, or rotating axis, and back in the precise order.

AI is helping organizations prevent unnecessary downtime by collecting data from running machines in the factory and using it to train AI models for predictive maintenance.

The sound of success

As engineers simplify the design process with artificial intelligence (AI), they’re exploring another use: influencing human emotion. For example, automakers are starting to use AI to make passengers of autonomous cars feel more comfortable.

“Designing an autonomous vehicle is more delicate than simply making sure it can avoid a collision,” says Herman Van der Auweraer, global director of research and technology development at Siemens Industry Software. “It’s about providing a feeling of comfort and perceived safety.”

Consider, for example, the sound of an autonomous car—the quiet whir it makes when braking or accelerating. As driverless vehicles gain mainstream traction, chances are consumers will expect them to sound like conventional cars. “Noise is something we want to minimize in a vehicle, but it’s more complex than that,” says Van der Auweraer. “A car can make a sporty sound—or it can sound powerful.”

Simulating a vehicle’s sound involves capturing the feelings the sound elicits, and that’s where AI comes in. Algorithms can collect and analyze data on human reactions to sounds and other stimuli, like motion—how a car turns a corner or passes another vehicle, for example. “AI can integrate these human feelings into parameters that can be used in a design environment” and generate the desired behavior in an autonomous car, Van der Auweraer says. “AI can help us develop these kinds of models.”

For example, hundreds of tools are used to manufacture metal engine blocks for commercial vehicles. These tools, which are stored in ultra-tall magazine cabinets, drill or mill bits of metal called workpieces with a high degree of precision. In automated manufacturing, a mechanical arm inside the machine removes tools from their positions on the shelf in a coordinated sequence and places them in a transfer compartment. From there, they're inserted into the spindles. This process is repeated for all workpieces. But because the transfer of each tool depends on the movement and position of hundreds of other tools, the process can lead to wait times of several seconds – moments that eventually add up.

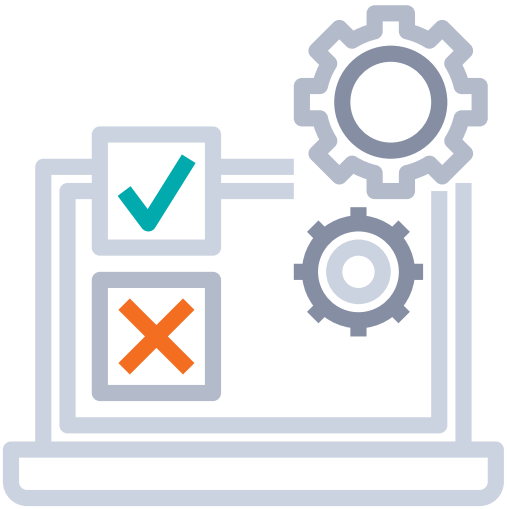
Fortunately, there's an app that promises to significantly reduce the time required for these processes. The app, which runs on Siemens' Sinumerik Edge platform, uses sophisticated mathematical optimization methods to optimally place a tool in its precise location according to the requirements of the next workpiece to be machined "within a millionth of a millimeter," says Zapf. What's more, he says, by detecting whether the right workpiece is in the correct position, the AI-powered app can significantly reduce production cycle time up to 20%.

A product aid, not panacea

Zapf warns that AI is not a silver bullet for product design. "Engineering knowledge is still needed to select the correct conditions for machine learning," he says. "It's not a black box where you just expect the truth to emerge. AI can lower the thresholds on development and ease the job for engineers, but in the end, you always need engineering know-how."

Yet, according to Siemens' Wyckaert, with best practices in place, "AI can be a means to help incorporate an engineering team's tribal knowledge into the design process." Senior-level engineers are always encouraged to share their understanding of information and processes that are not formally recorded or stored in a shared resource. By training new algorithms and building innovative models, Wyckaert says engineers can essentially integrate their "years of accumulated knowledge" into systems that will be available to engineering teams across the organization.

That's not to suggest that AI will ever replace the expertise and understanding of a seasoned engineer. "We will always have to be able to explain why an AI system reacts in a certain way," says Zapf. That's different from an e-commerce retailer relying on AI to recommend a book. The retailer can't be held accountable for the books the algorithm suggests, he says. "But the way a car drives, or the way a wind turbine works – engineers need to be able to explain why a machine reacts the way it does."



"With AI, it's possible to explore many more design variances than with linear engineering, where engineers have to test each different use case and explore the results of each one,"

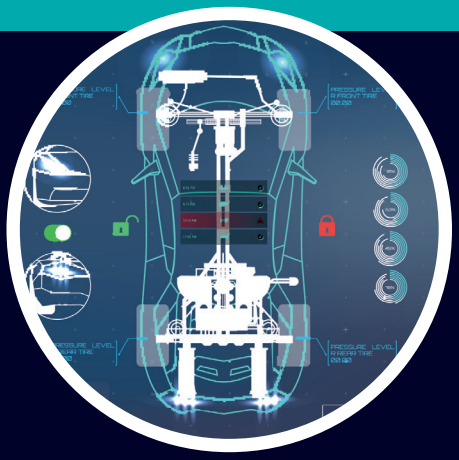
Bernd Zapf, Head of Development, New Business, and Technologies, Heller Group

In the meantime, AI will continue to offer engineers endless possibilities for new product design and development. "It's possible to explore many more design variances than with linear engineering, where engineers have to test each different use case and explore the results of each one," says Zapf. "Rather, AI can learn what worked and what didn't, and from there, propose designs that engineers might not have ever considered."

For more on AI in industrial applications, visit www.siemens.com/artificialintelligence.

The product life cycle in the 21st century

Many products today – whether cars or copiers or turbines – are conceptualized digitally, using AI and simulation, and get continually monitored as they move into production and use.



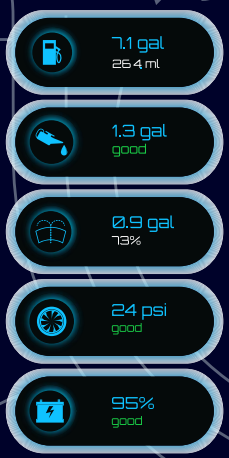
DESIGN

AI and simulation technology are used to create a virtual model of a product – for example, an automated manual transmission (AMT) system for a car – that engineers can test and manipulate.

Software also helps plan the production of the product and choose equipment such as robots and conveyor belts.

PRODUCTION

Code from the simulation model gets transferred to production-line systems, which automate production of the AMT.



PERFORMANCE

Data from a newly minted AMT gets collected and fed into training for AI models.

The models detect signs that maintenance is needed.

Predictive maintenance makes it easy to identify problems and predict when systems or machinery will break down.

"Product design gets an AI makeover" is an executive briefing paper by MIT Technology Review Insights. It is based on research and interviews conducted in February 2021. We would like to thank all participants as well as the sponsor, Siemens Digital Industries Software. MIT Technology Review Insights has collected and reported on all findings contained in this paper independently, regardless of participation or sponsorship. Laurel Ruma and Jason Sparapani were the editors of this report, and Nicola Crepaldi was the publisher.

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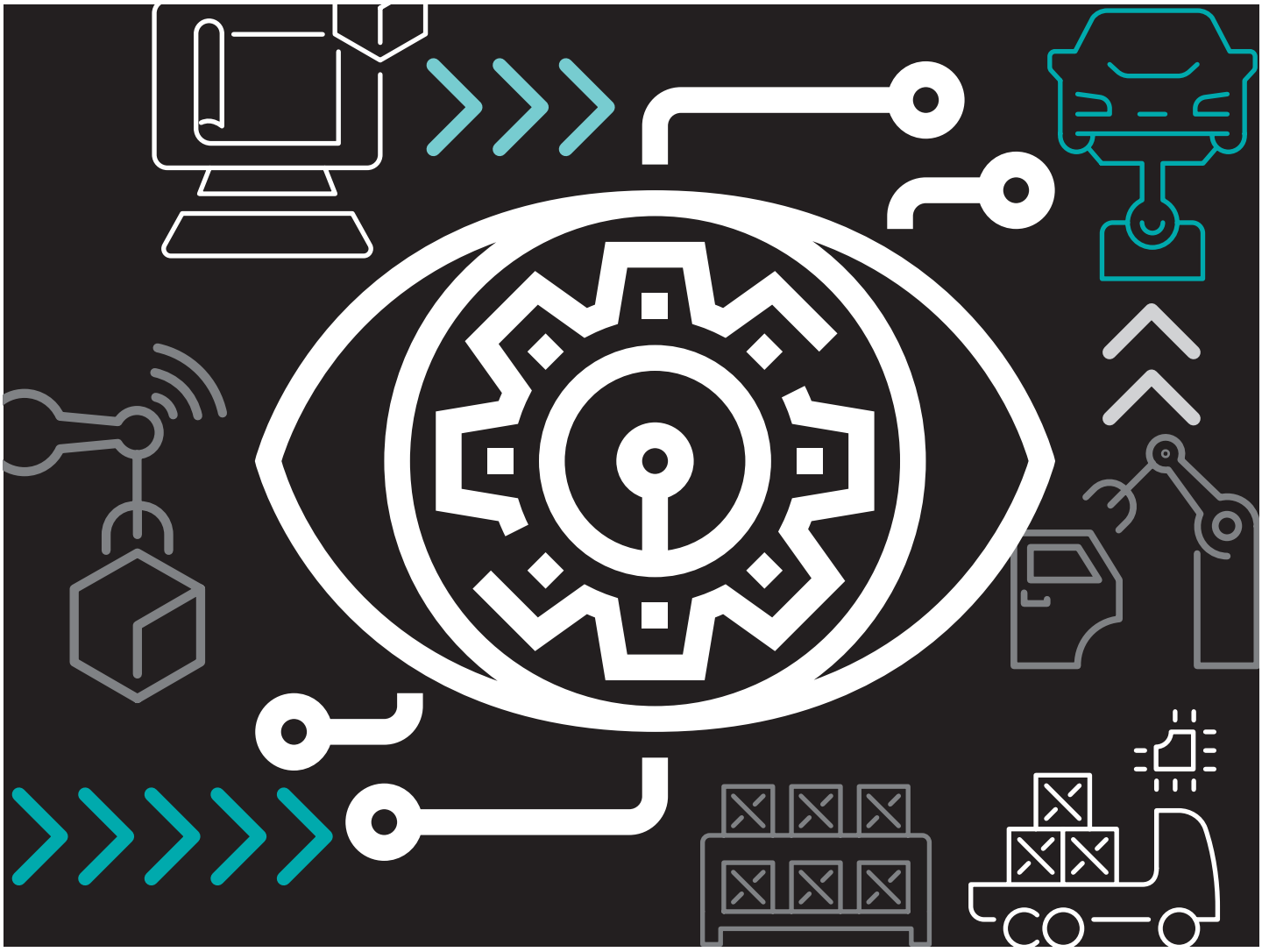

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