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How AI is Revolutionizing Manufacturing
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Artificial intelligence and machine learning are transforming the manufacturing industry. According to a report released late last year by the World Economic Forum, the combination of artificial intelligence, advanced robots, additive manufacturing and the internet of things (IoT) will combine to usher in the fourth industrial revolution.

The majority of manufacturing companies, 80 percent, expect to see positive effects of AI initiatives, with a predicted increase in revenue of 22.6 percent, and a 17.6 percent reduction in costs.

In fact, manufacturers are already using artificial intelligence and machine learning technologies to reduce equipment downtime, spot production defects, improve the supply chain, and shorten design times. However, the lack of skilled personnel, data, and standards is keeping many companies from forging ahead.

General Electric leads the charge
One of the companies at the forefront of this new wave of industrial transformation is General Electric, which has been motivated to explore the use of AI due to declining productivity in its sector.

"Up until 2010, productivity growth was in the 4 to 5 percent range," says Colin Parris, the company's vice president of software research. Then the industry changed. Experienced engineers were retiring, while the new geographies GE was in, including India and China, had primarily a young workforce.

Meanwhile, Parris says, customer requirements were rapidly becoming more complex. There were new routes to destinations with extreme weather conditions and air pollution that affected the jet engines that GE produced. And social media magnifies the impact of any outage, forcing customers to demand better reliability and less downtime.

At the same time, customers expected prices to continue to fall.

"People say you can't predict the future," Parris says. "You definitely can. People want things cheaper."

To address this issue. General Electric turned to artificial intelligence and machine learning, starting with services it provided to its customers, such as jet engine and turbine maintenance. Then GE applied AI to internal manufacturing, followed by design, and then internal processes, such as data center operations and human resources.

"We've been using models and forms of analytics in services for last 10 to 15 years at least," says Parris. Five years ago, GE began using machine learning and digital twins, which provide a virtual representation of a piece of machinery, such as a wind turbine, or a grouping, such as a wind farm. Digital twins can also be used to represent an assembly line, an entire factory, or a procurement process.

At GE, digital twins are used to model performance, predict failures, and allow for rapid testing of potential improvements.

"We can predict which things are going to fail, so we have the right engineers, and we have the right parts in inventory," Parris says. "We can get [better] fuel efficiency and fly planes longer without bringing in parts for service unnecessarily. We've been saving millions of dollars for customers."

Another side benefit of having a digital twin of every piece of equipment, system or process was that GE could take advantage of additive manufacturing — 3D printing — to create custom parts, instead of having to rely on replacement parts that had to be manufactured in bulk, on traditional assembly lines.

"As the years go on, the machines degrade differently," he says. "Now I can say, 'Can I design parts specifically because in this machine used in this way we're seeing damage in the training edge, or more cracking in this blade?' Additive manufacturing allows me to build one part at a time, to solve the unique problems that this machine is having in this environment, rather than having to build these huge factories and turn out hundreds of these parts that will work on average. Before, I had to spend hundreds of millions of dollars to build the factories. Now I can print one part at a time, and can constantly adapt the body of the machine, and the mind of the machine. Now I have a machine that can continuously adapt itself to be more and more productive, what we call an immortal machine."

"This is where I think the future gets very interesting for GE," he adds.

The promise of predictive maintenance

Other manufacturing companies are also looking at using artificial intelligence and machine learning to cut costs and improve performance.

Florida-based Jabil, a Fortune 500 company that performs contract manufacturing for major global brands, began a push to using artificial intelligence several months ago to spot manufacturing defects and predictive maintenance.

For example, in one of its factories in China, automated optical inspection machines have several cameras looking for defects in circuit boards the company is manufacturing.

Basic image recognition technology was already in place to look for defects, but 35 to 40 percent of the boards flagged by the system and sent to human operators for review actually had no problems at all.

"Operators have two seconds per image, and some of those boards can be quite large and have hundreds of components," says Ryan Litvak, the company's senior manager. "The challenge was to capture the intuition of the operators and with a high accuracy level to be able to tell yes, this is actually a defect, or no, this is not a defect."

By reducing the number of boards flagged, without sacrificing accuracy, Jabil will be able to have its operators spend more time on the problematic boards, or be reassigned to other, more value-added tasks.

"We've been able to show really good results," he says. "Capturing between 93 and 98 percent of the true defects, which is pretty high, and being able to eliminate about 70 percent of the passed components, the ones that are not defective."

The proof of concept involved two production lines, he says, which had very similar equipment and processes. Now, Jabil is working on generalizing it to different lines, to handling larger volumes of data, and to incorporate the new decision-making process directly into the workflow.

Another area that the company is focusing on is predictive maintenance, where the challenge is getting the needed data.

"There are many different systems in use, a lot of different equipment," says Litvak. "Some of it has their own systems for doing maintenance, some doesn't. Some providers track maintenance on spreadsheets, some have home-grown systems."

He says that Jabil's data scientists are working on normalizing this data, and collaborating with experts at Microsoft to build the deep learning models required to predict equipment failures.

According to research from McKinsey & Co., AI-enhanced predictive maintenance of industrial equipment will generate a 10 percent reduction in annual maintenance costs, up to a 20 percent downtime reduction and 25 percent reduction in inspection costs.

There's been a lot of interest in recent months in pilot projects for specific use cases of artificial intelligence, says Matthias Kässer, a partner in McKinsey's Munich office.

The biggest impact is using computer vision and sensor data in quality inspections and in predictive maintenance.

"We currently implement such vision-based AI applications at several companies unlocking tremendous potentials," he says. "However, to fully leverage the potential, companies will need to quickly transfer the learnings from these pilots into holistic AI transformations across functions and processes. This is where the real work starts."

A question of accuracy

Another manufacturing company that is just starting to use image recognition to spot manufacturing problems is Lennox International, a Dallas-based maker of HVAC systems.

"The accuracy level is much higher than with human beings," says Sunil Bondalapati, the company's director of IT, advanced and emerging technologies. "Right now, we are at about 20 percent higher accuracy rate. We don't see it as a headcount value proposition, we see it more as an accuracy value proposition."

Lennox also leases equipment to business customers, and, like General Electric, improving maintenance is a core need.

Today, the HVAC equipment transmits information about its performance to the cloud, on the order of 8 million new records per hour.

Adding intelligence allows the company to predict equipment failure in real time, which wasn't possible before.

"That's where AI comes in," says Bondalapati. "It is able to retain the context and the memory of the particular equipment from, say, two years ago — how did it perform under 105 degree temperature when the humidity level was at this level, how did it perform then, how is it performing now."

Lennox began the project four months ago, and the results were promising enough that it decided to begin a full rollout of the technology over the next four months.

Calculating the return on investment on the maintenance side will be tricky, he says. "How do you calculate ROI when the equipment doesn't fail? We're going to have to do some data gathering over the next year on that."

But Lennox already saw its storage and computing costs cut in half, as it was able to use technology from DataBricks to consolidate the data.

"We went down from 20 cores to four cores," he says.

Another use of AI for the company is on the financial side.

Take, for example, calculating how much the company should set aside for warranty liabilities.

"Previously, we just used to approve a certain dollar amount — $20 million or $30 million — there was no scientific way of knowing how much money you needed to put aside for customers returning products," says Bondalapati. "Today, using AI, we are able to predict the failure rates on each component, and tell the warranty department how much to set aside, and we are able to tweak it every day as we get more data."

He says that he expects a 10 percent decrease in required set-asides as a result.

The power of AI proliferates

Lennox is also using artificial intelligent to look for accounting problems.

"We do millions of general ledger postings," he says. "It's not humanly possible to go through all the postings that happen every day."

He says that his team is constantly looking for opportunities to use artificial intelligence to help the business.

"We are like an internal consulting organization," he says. "We are constantly selling this. We speak with the business units and other stakeholders every week and come up with other use cases for them to try out."

He says that Lennox is a little early to the AI game. "For industries like ours, AI is a hard road, and it requires a lot of selling to a very skeptical audience."

AI’s chief limitations today: Skills and data

Machine learning and advanced analytics play an important part in predictive maintenance and other aspects of the manufacturing process.

According to a recent study by PricewaterhouseCoopers, 78 percent of manufacturing companies have deployed or are planning to deploy predictive maintenance technology, followed by 73 percent for manufacturing execution systems, 60 percent for digital twins, and 59 percent for robotic process automation.

Only 29 percent are using or planning to use artificial intelligence, which PricewaterhouseCoopers defines as moving beyond machine learning and advanced analytics to making independent cognitive decisions.

Today, most of the focus in about embedding artificial intelligence and machine learning technologies in order to cut costs, says Kumar Krishnamurthy, a PwC principal who focuses on IT strategy. "But my prediction is that some of these technologies are going to help companies scale and drive productivity at a different level."

Demand from customers and pressure from industry disruptors will force manufacturing companies to change, he says.

However, the technology isn't quite as mature yet as people believe it to be, he says. In addition, the lack of AI skills, and lack of usable data, is also hindering the process.

According to the PricewaterhouseCoopers survey, 52 percent of manufacturing companies implementing AI say that lack of skilled people is a major challenge, and 42 percent point to reliability of data.

Building AI into the design process

One group trying to overcome both the skills and the data problem in the difficult and extremely time-consuming design phase of the manufacturing process is the Palo Alto Research Center, the Xerox company behind such innovations as laser printing, object-oriented programming, the graphical user interface, optical storage, and many other foundational technologies.

Artificial intelligence can take functional requirements, cost, regulatory, and manufacturing constrains, and come up with designs that human beings would not have thought of, says Ersin Uzun, PARC lab manager and vice president of R&D.

"If I ask you to design something that would let me hold liquids, you would probably start with something like a cup," he says. "You would not necessarily come up with a camelback design immediately."

Once something is designed, PARC is also working on creating technology that would figure out how to build it, using both subtractive and additive manufacturing methods, and keeping in mind the imperfections that are introduced by different design and manufacturing choices.

"Today, you design something, send it to a manufacturing expert, they figure out how to manufacture it, then engineering and analysis people look to see if the manufactured piece satisfies our operational requirements," he says. "It takes months."

Manufacturing is the rare area where physical capabilities are far ahead of what software can handle, Uzun says.

"We have new materials that are extremely exciting, new additive manufacturing technologies, hybrid manufacturing machines," he says. "But when you look at the software that people are using, it's a generation behind of what you can achieve with the materials and tools that you have. We have these machines that can do both additive and subtractive manufacturing right now, but you can't really design for that manufacturing capability. So it all happens manually, which basically is beyond the cognitive abilities of any humans for most of the complex manufacturing needs we have today."

In order to have design tools that can keep up with the pace of change in material science and manufacturing technologies, artificial intelligence needs to be built into the tools themselves, says Sai Nelaturi, area manager at PARC.

PARC is also working on creating standards and protocols that allow all the disparate systems in manufacturing plants to talk to each other, and creating AI-driven algorithms to optimize for energy use, throughput, efficiency, and safety.

PARC doesn't make the technology itself, Uzun says. "We are an innovation partner and technology provider. We create those technologies, get them to prototype stage, and find the right partner to take it to the market."

Today, PARC is working with both large and small manufacturing companies to test the technologies and bring them to market.

AI technologies can will help small and medium-sized manufacturers to become competitive — and help bring manufacturing jobs back to the United States, he says. "And that will create other kinds of jobs around this ecosystem when that happens."