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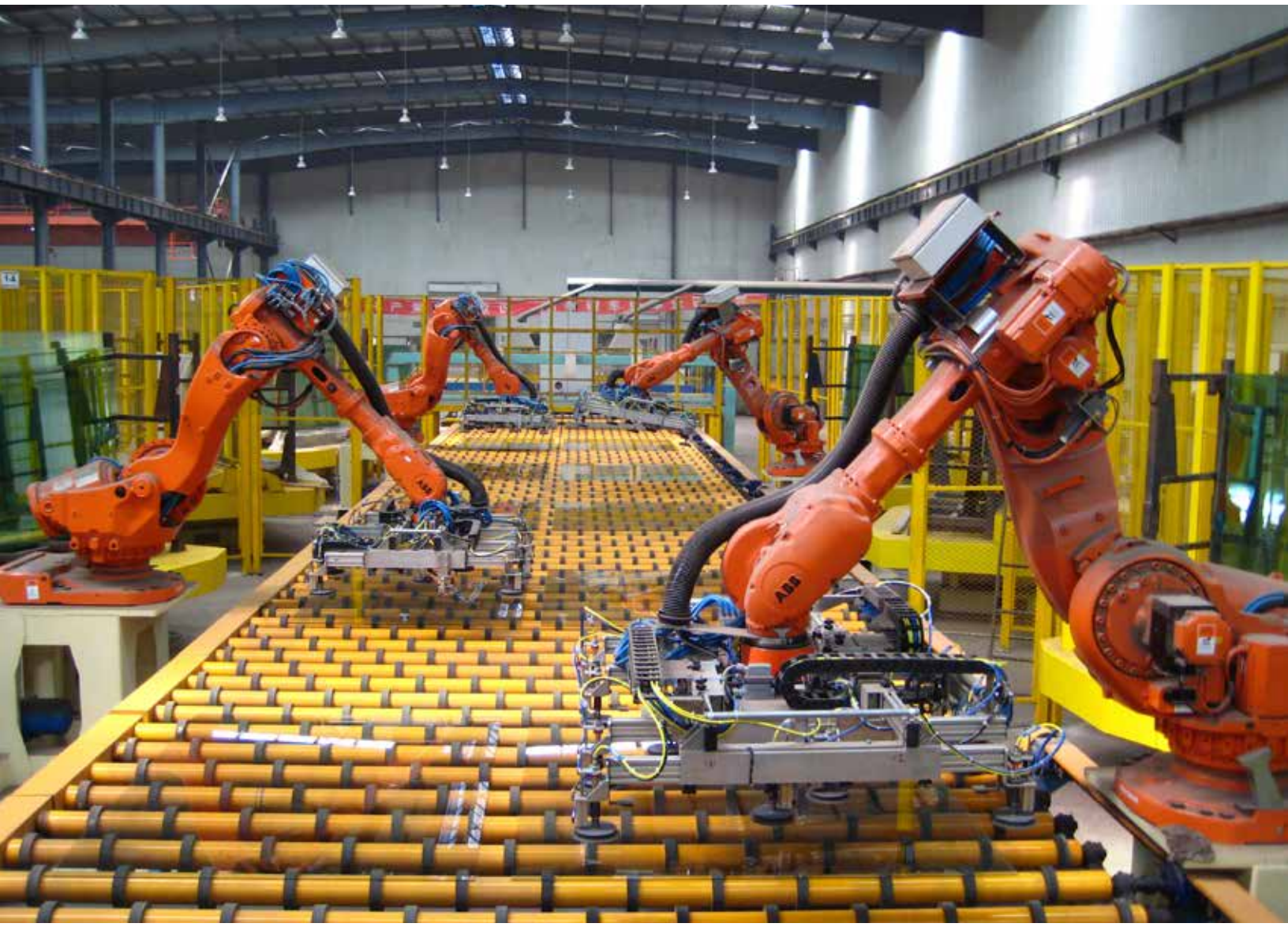

Building a Smart Factory with AI and Robotics

John Edwards, ***Robotics Business Review***

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BUILDING A SMART FACTORY WITH AI AND ROBOTICS

Artificial intelligence-driven automation is poised to transform global manufacturing.

Automation transformed 20th century production lines. Now, a combination of artificial intelligence and robotics is taking automation to the next level: the smart factory.

AI allows businesses to create new production processes and optimize existing methods. Using the right AI software, businesses can make highly customized things — ranging from parts to entire systems — more quickly and at a lower cost, noted Howie Choset, a professor of robotics at the Carnegie Mellon School of Computer Science.

"I believe the right AI, just like other innovations in manufacturing, will introduce completely new processes, thereby creating the 'must have' products of tomorrow that we cannot even conceive of today," Choset said.

Today's factories are essentially a series of processes, consisting of materials, tasks, and information flows. For increased productivity and capacity utilization, all of these processes have to run seamlessly and without interruption.

"AI enables various aspects of the operation to do exactly that: predict failures to prevent downtime; do optimal production scheduling based on orders in hand; and generate forecasts, inventory, and delivery times," explained Jagannath Rao, Siemens' senior vice president for Internet of Things (IoT) and go-to-market strategy. "[AI also allows manufacturers to] apply sophisticated robots for accuracy and quality and, finally, self-organize logistics for seamless deliveries."

"AI has left the workbench; it has entered the factory," Rao declared.

THE CASE FOR FACTORY AI

AI is rapidly becoming an essential technology that's helping manufacturers inject next-level automation into their processes. In factories, deep learning can be leveraged in several areas, including planning, scheduling, and predictive maintenance.

"This does not mean that AI is meant to be unmanaged," noted John Santagate, service robotics research director at market research firm IDC. "There should still be people involved in reviewing the AI decision-making so that when the outcome of an AI enabled decision is suboptimal or does not

include some key piece of information ... a person can tweak the model so that the system can continue to learn.

AI is a technology that's built upon a strong history of inputs and outputs.

"AI does not inherently know what to do under unknown circumstances," Santagate explained. "However, where a strong history of inputs and outputs exists, AI is able to make a best fit decision and will learn from the outcome of each decision that it makes."

When properly applied, machine learning (a technique that gives computers the ability to learn without being explicitly programmed) can bridge the gap between traditional human-defined business workflows and the big data era that industry is now entering.

AI has the potential to radically improve the efficiency and effectiveness of decision-making in highly complex data environments all while embedding an ever-increasing amount of knowledge within these intelligent systems."
—Jeff Erhardt, VP of intelligent systems, GE Digital

"Currently, a paradox exists where all of the data being collected is of relatively little value without being used in the context of critical business decision-making," said Jeff Erhardt, vice president of intelligent systems at GE Digital. "But at the same time, the sheer volume and complexity of this data is overwhelming the ability for humans to manage decision-making within these workflows."

Machine learning integrated into production applications, or intelligent systems, solves the paradox by mimicking human decision-making within workflows in a highly scalable and continuously improving manner.

"AI has the potential to radically improve the efficiency and effectiveness of decision-making in highly complex data environments all while embedding an ever-increasing amount of knowledge within these intelligent systems," Erhardt explained.

AI can play an integral role in allowing a manufacturer to manage and optimize the performance of its assets and business processes.

"For example, intelligent software systems can help plant operators predict maintenance issues and equipment failures with higher accuracy and more advanced warning than ever before," Erhardt said.

In the manufacturing world, the large-scale collection of actionable industrial data can pave the way for improved safety, efficiency and profitability. Yet sorting through vast amounts of data to achieve these goals has begun to reach the limits of human capacity.

"Artificial intelligence and machine learning are key to delivering on this promise and, in turn, opening up new business models," said Erhardt.

AI can also help on a smaller scale, by enabling production operations to be more nimble when switching among smaller batches or customizing products.

CURRENT AI AND ROBOTICS

AI has already begun playing an important role in automation and robotics. In agriculture, for instance, John Deere now produces unmanned farming vehicles with highly autonomous capabilities.

"Applying machine learning and cloud services to robotics automation creates new opportunities for manufacturers to achieve higher reliability, increase productivity and more," observed Rian Whitton, an AI and robotics industry analyst at ABI Research.

Many current-generation mobile and collaborative service robots also feature some degree of built-in AI.

"These robots are performing functions autonomously and, as such, are continuously making decisions," Santagate said. One simple example would be the use of a robot to move materials and components autonomously between workstations.

"These robots are moving in areas where people are working and as such must be able to recognize an obstruction in their path and adapt to a fluid

environment," he added. "This is a common usage of AI and robotics in factories."

AI enables robots to work in a manner where efficiency and productivity are maximized.

"For example, if one of the robots is idling, it can communicate that fact to the other robots and go into an energy-saving mode on the line," Rao said. "Since collaboration is enabled, it happens in real time."

$4.8B

VALUE OF THE MARKET FOR AI IN MANUFACTURING BY 2023, ACCORDING TO A 2017 REPORT BY MARKETS AND MARKETS.

Virtually any business process that can be automated is a prime candidate for AI-driven robotics. "Certainly, areas that require the unstructured thought and creativity of humans are not candidates, but the areas where decisions are based on a long history of known outcomes are prime candidates for AI," said Santagate.

Choset predicted that the automotive, aerospace, and electronics industries will be leading adopters of AI-augmented robotics. Logistics organizations are also well-positioned to take advantage of the technology.

"I'm hopeful that the composites, textiles and food industries are also going to embrace robotics," he added.

Sachin Garg, associate director for electronics and semiconductors at market research firm Markets and Markets, said he believes that logistics and warehouse operators will be the most immediate beneficiaries of AI-driven robots.

He pointed to Amazon Robotics' Kiva Robot as a prime example of an early AI-enabled industrial robot. Several U.S. retail warehouse operators already using such autonomous mobile platforms, Garg observed. "Such robots have been helping their owners generate more revenue," he added.

"The incorporation of AI into articulated robots is still in its nascent stage," Garg stated. "However, we will not be surprised if AI is integrated into robots used for production or assembly plants sooner than we anticipate."

He noted that in October 2016, FANUC collaborated with Nvidia to implement AI in the FANUC Intelligent Edge Link & Drive (FIELD) system, designed to increase productivity and bring new capabilities to automated factories worldwide.

"We believe the AI industry is at the tipping point of disruption and value creation," he said. "This will likely change the way factories operate, going forward."

BOTTOM-LINE BENEFITS

Next-generation automation promises to increase productivity and reduce costs by enhancing efficiency and reducing waste throughout production. The ability to learn on the job allows AI-powered robots to deal with unusual situations, such as customization requests and the arrival of large, unexpected orders.

"Making things more efficient and reducing operational costs enables owners to make more investments, which can create more jobs and allow [for] retraining the workforce for higher level jobs," Rao observed.

By taking over highly demanding or dangerous processes, machine learning and robots enable workers to focus on tasks that people can perform better while taking over processes that can be effectively automated.

"This becomes a significant lever to improving productivity and efficiency in the operation," Santagate said. "Through productivity and efficiency, organizations deploying [AI and robotics] are seeing cost and profit benefits as well," he added.

Many of the manual, tedious processes currently performed across industrial facilities, such as issuing work orders for equipment maintenance and scheduling inspections, can be automated by leveraging AI.

"Service operation costs for the 10 biggest industrial sectors amount to $1.4 trillion annually, and there are more than 20 million field technicians working globally," Erhardt said.

ANDREW NG LAUNCES STARTUP FOR AI IN MANUFACTURING

Andrew Ng, a Stanford University professor and former Google Brain and Baidu AI leader, last year founded Landing.AI. The startup is developing algorithms to help manufacturers train employees, manage supply chains, and improve product quality.

Landing.AI has already partnered with smartphone maker Foxconn.

"AI technology is well suited to addressing the challenges facing manufacturing, such as variable quality and yield, inflexible production-line design, inability to manage capacity, and rising production costs," wrote Ng.

With automated maintenance and inspection processes in place, organizations can dedicate more time and resources to priority business initiatives and optimizing operations.

"The important part to note in this is that machine learning is most — or only — effective when applied to large-scale aggregated data as part of an application or workflow that captures feedback on an ongoing basis," GE's Erhardt added. "This is particularly true in the industrial world, where the data is noisy and observable events — i.e. failures — are rare."

Supplementing robotics workforces with AI will make them more productive per unit, offsetting the need to take on large numbers of temporary workers for important production work, such as quality control.

In Japan, for instance, due to high wages demanded by permanent workers, 37.5% of the workforce in 2016 consisted of temporary employees.

"It has been mentioned as one of the key reasons for failures in assuring quality within companies like Nissan, Subaru, and Kobe Steel," Whitton said.

BUILDING A HYBRID WORKFORCE

An emerging generation of smart, collaborative robots will help factories speed production in several critical areas. Current use cases include assembly and material handling — including picking and packing — and even automated factory floor security, IDC's Santagate noted.

While the "lights-out" factory is the goal of some automation developers, the

real challenge will be combining robots, AI, and human workers for maximum efficiency.

Direct cooperation between robots and humans is already gaining traction in hospitals and other healthcare facilities, where they help patients move in or out of beds and wheelchairs.

"In factories, robots can assist humans in routine and strenuous jobs that entail risks related to physical health," explained Rohit Waghadhare, an assistant manager at Markets and Markets.

Automation will free factory workers from mind-numbing, ergonomically taxing, and dangerous tasks, CMU's Choset observed.

"I envision a future where the worker and automation will be working together," he said. "Ultimately, I am looking forward to the new processes that automation is going to create."

Down the road, AI-enabled robots will perform virtually all sophisticated production tasks, allowing human workers to address higher-level tasks. These include making design improvements, implementing sophisticated systems, achieving enhanced safety standards, and using advanced analytics to find further productivity innovations.

"This convergence of artificial and human intelligence will enable manufacturers to lift time to market, flexibility, efficiency, and connectivity to a new level," Siemens' Rao predicted.

Siemens has invested $10 billion in U.S. software companies over the past decade as part of its push to take advantage of big data, the cloud-based MindSphere open operating system, and AI.

The biggest challenge will be enabling safe and reliable handoffs between robots and humans during specific workflows and processes. "These situations can raise safety and process-continuity issues," Rao noted.

Faulty and incomplete handoffs can lead to accidents, production loses and even disciplinary issues. "The legalities and ethical considerations haven't evolved to deal with these situations and need to be tackled," Rao observed.

As the fences separating workers from robots gradually fall away, concerns about safety are growing. "The question of ethics eventually comes up," Choset said.

He said he believes that a robotics ethics policy should be similar to the types covering the introduction and use any new tool, focusing on issues such as job security, responsibilities, and safety.

COBOTS AND DEXTERITY

On the bright side, Whitton points out that collaborative robots are designed to run at a much lower power rate than their traditional counterparts and, therefore, do not generally pose major safety concerns in the event of a failed handoff or collision.

"At the same time, there are advances being pursued in computer vision and image recognition that will allow robots to have the dexterity and preventative capability to avoid contact with nearby human workers," Whitton noted. "Look at Veo Robotics as an exemplar of this trend."

"AI should be empowering to people by eliminating the mundane repeatable work and allowing humans to focus on what they can uniquely do: use creativity to innovate and solve the hardest problems," Erhardt stated.

In addition, as machine vision and machine learning enable cobots to be safer and more flexible, they can extend the benefits of automation to small and midsize enterprises.

PREVENTATIVE MAINTENANCE

Historically, maintenance and repair tasks have been procedural and scheduled, but advances in big data processing, machine learning, and telematics now give manufacturers the opportunity to implement predictive maintenance.

"Earlier this year, IBM conducted studies in predictive versus scheduled maintenance and found potential cost reductions of 25%, a 75% reduction in breakdowns, a 45% reduction in downtime and a 25% increase in productivity," Whitton said.

Modern robots, much like modern cars, are becoming increasingly reliant on software management to operate at peak performance. From a physical perspective, robots are a connected "thing."

"This means they are able to send data about their condition to the operation that is then able to leverage an IoT platform and analytics to monitor the health of each robot and engage in predictive and preventative maintenance," Santagate said.

Predictive maintenance is typically built directly into AI-enabled robots. "It's a part of the AI," Rao observed. Such an advanced robot is designed to monitor and manage its own health. If it sees abnormalities, it identifies them long before it goes down and can even order the spare part it requires, along with work instructions, to avoid downtimes, he noted.

According to Whitton, AI-enabled robotic prognostics will initially be led by the automotive sector. ABI projects that by 2020, global automotive prognostics spending -- including predictive maintenance -- will total over $ 21 billion.

"Expect robotics-related prognostics to lag behind that somewhat, likely reaching that figure closer to the middle of the decade," Whitton said.

HYPE OR REALITY?

The public's perception of intelligent robots is both helping and hurting the technology's use and acceptance. Robots and AI are not nearly as far along as many people think, Santagate noted.

"Science fiction has given this vision of AI-enabled robots that walk among humans and become far superior to people through computer-driven intelligence," he said. "This is not the case now or in the near future."

Control, trust, and transparency will prove critical to the successful integration of AI into critical business processes, Erhardt advised. "By control, we mean providing business owners the power to decide where they want to operate their intelligent system on the spectrum from manual to augmented to automated decision-making based on their desired risk-return trade off," he noted.

Trust will be derived from control, incrementally delivering consistent and stable results to end users within the context of a constantly changing environment. "Transparency … is about providing business owners with an understanding of the reasons why decisions were made within these intelligent systems," Erhardt observed.

Although there may be some hiccups along the way, we are not too far away from creating learning systems or algorithms that will not only be on par with humans, but will also exceed average human capabilities, Waghadhare noted.

"Factories without humans is not a hype; it will be a reality — the only question is when," he said. "In our opinion, it will be much sooner than most experts think it will be."