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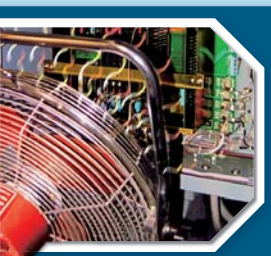

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From the Editor

By Rehana Begg, Editor-in-Chief

The View from the Frontline: **Separating Robotics Hype from Reality**

Workers on the ground should have a say in introducing new technologies, such as autonomous robots.

TRADE SHOWS ARE a veritable stomping ground for technology editors searching for ideas, evaluations and analysis about the latest advances and products. But a chance encounter with a conference attendee had me reconsidering my usual sources and where they come from.

I met Christopher Thrasher, a delegate attending Automate 2024, as I was leaving a coffee shop and making my way to the bus stop. We struck up a conversation. He explained that he was an engineering technician who programs robots to weld the tanks for water heaters. This was his first trade show.

"What are your impressions so far?" I asked.

"Those AGVs are pretty cool," Thrasher said. "We're talking about automating our forklift operation. So, that would save a lot of time right there, by just loading the metal for us at the stacks, anywhere from two to three times. Some of those AGVs can do what we want them to do. Our metal stacking process is a rather easy process, and an automated vehicle could do it."

His team has a lot of downtime waiting on an operator to return from other operations, and he reckoned that having an AGV forklift queued to de-stack and restack sheets of metal would make a big difference. Thrasher's employer, A.O. Smith Corporation, will need to make the cost-benefit analysis, but his level of excitement and commitment to finding cost-savings and making gains in productivity shouldn't be lost to decision-makers.

Many organizations are already deploying mobile robots and will expand their fleets in the next three years. According to Gartner research, more than 75% of companies will have adopted some form of cyber-physical automation within their warehouse operations by 2027.

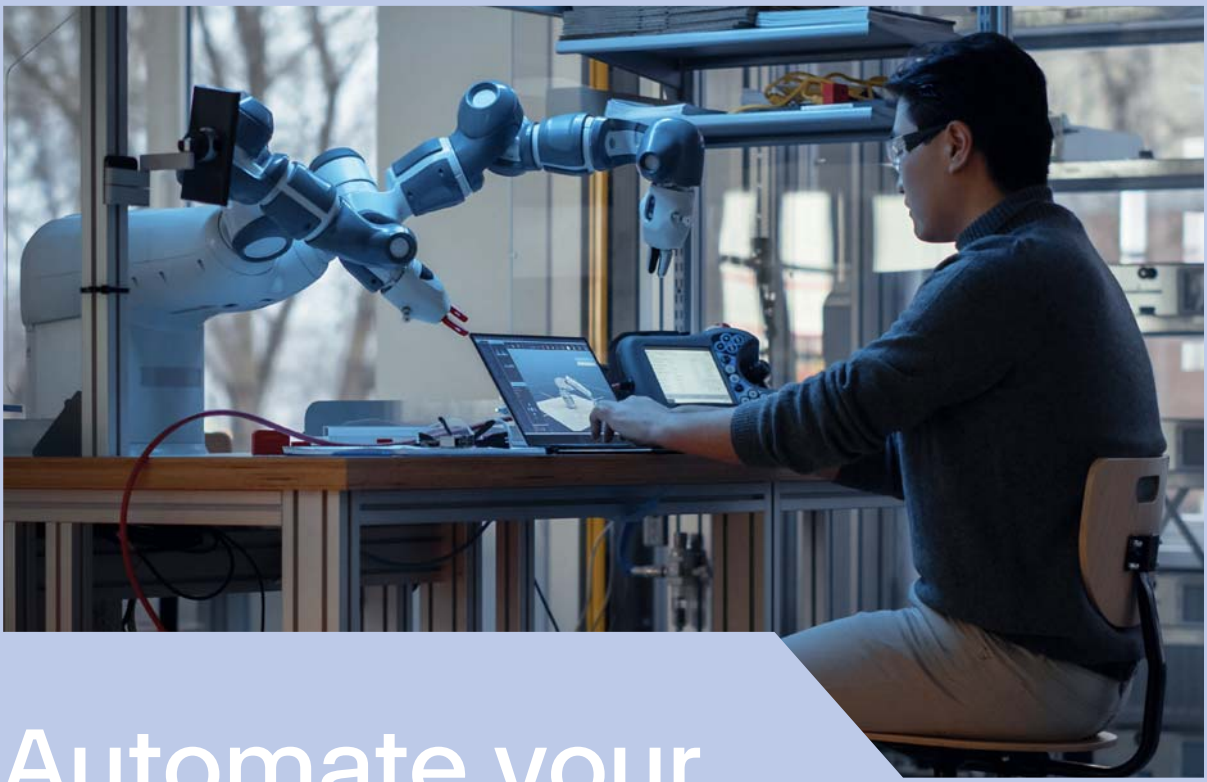
Gartner's Hype Cycle for Mobile Robots and Drones estimated that smart robots (AI-powered mobile machines designed to autonomously execute one or more physical tasks) are "about five to 10 years away from reaching the "plateau of productivity," that is, mainstream adoption. Swarming robots, light-cargo delivery drones, in-aisle cobot pickers, autonomous mobile robots, mobile robotic goods-to-person systems and robotic cube storage systems are about two to five years away from reaching the plateau.

Research, in many cases, responds to challenges by developing adoption frameworks from the decision-maker's perspective. This is helpful, of course, but by themselves they are incomplete. What's missing is a boots-on-the-ground perspective, which will ensure technology introductions are designed in a long-term, human-centric and effective way. A World Economic Forum report corroborates this view. When employers explain the rationale behind technological change, workers are more receptive to the change.

And, as the robotics package in this issue well illustrates, most robotics and automation solutions tend to be designed to solve repetitive, menial tasks.

"Whenever you replace a welder, they don't necessarily realize plants still must have somebody there with that robot," said Thrasher, who is augmenting his associate's degree in electrical engineering technologies with a bachelor's in mechatronics engineering. "We train individuals to operate robots. So, a lot of times they think it has taken their job. But really, they'll be trained for another skill set that is useful. Automation is where it's at." ■

Let me know what you think. Reach me at rbegg@endeavorb2b.com.



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EDITORIAL
Editor-in-Chief: **Rehana Begg**
rbegg@endeavorb2b.com

Managing Editor: **Jeremy Cohen**
jcohen@endeavorb2b.com

Technical Editor: **Sharon Spielman**
sspielman@endeavorb2b.com

Contributing Editor: **Sara Jensen**
sjensen@endeavorb2b.com

Market Leader - Electronic & Mechanical Group: **Michelle Kopier**
mkopier@endeavorb2b.com

ART DEPARTMENT
Group Design Director: **Anthony Vitolo**
tvitolo@endeavorb2b.com

Art Director: **Jocelyn Hartzog**
jhartzog@endeavorb2b.com

PRODUCTION
Production Manager: **Sam Schulenberg**
sschulenberg@endeavorb2b.com

Ad Services Manager: **Deanna O'Byrne**
dobyrne@endeavorb2b.com

AUDIENCE MARKETING
User Marketing Manager: **Debbie Bouley**
dbouley@endeavorb2b.com

Article Reprints: reprints@endeavorb2b.com

LIST RENTAL
Smartreach Client Services Manager: **Kelli Berry**
kberry@endeavorb2b.com

SUBSCRIPTION SERVICES
OMEDA: machinedesign@omeda.com
847-559-7598 or 877-382-9187

DIGITAL
VP of Digital & Data Innovation: **Ryan Malec**
rmalec@endeavorb2b.com

SALES & MARKETING
Patrick Carmody
pcarmody@endeavorb2b.com
AK, AR, AZ, CA, CO, HI, IA, ID, IL, IN, KS, KY, LA, MI, MN, MS, MO, MT, ND, NE, NM, NV, Western OH, OK, OR, SD, TN, TX, UT, WA, WI, WY, Western Canada

Brandy Bissell
bbissell@endeavorb2b.com
DE, MD, NC, NJ, NY, Eastern OH, PA, SC, VA, WV

Liz Stott
lstott@endeavorb2b.com
AL, CT, FL, GA, MA, ME, NH, RI, VT, Eastern Canada

Holger Gerisch
hgerisch@endeavorb2b.com
UK, Europe (not Italy

Diego Casiraghi
diego@casiraghi-adv.com
Italy

Helen Lai or Charles Liu
helen@twoway-com.com or liu@twoway-com.com
Pan-Asia

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Endeavor Business Media, LLC
30 Burton Hills Blvd, Ste. 185, Nashville, TN 37215
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10 TIPS FOR AUTOMATION SUCCESS

Tried-and-true pointers for leading successful robotics and automation implementations—all culled from peer networking at conferences.

MANUFACTURERS FACE A quintuple-whammy: the need to improve productivity; fight cost pressures; boost quality and repeatability; build a more robust supply chain (e.g., via reshoring); and fill 82,500 welding jobs annually between 2024 and 2028.

Not to sound the alarm, but American companies need to get into automation quickly. The good news is that everyone is in the same boat. Automation technology is democratic; it is open to everyone. Success comes when companies create a culture that embraces automation, sets itself up for success and proceeds wisely.

So that welding experts can learn from their peers, the American Welding Society (AWS) holds automation-related educational events, such as the AWS Welding Automation Expo & Conference held late last year. Following are 10 key takeaways from presenters at the conference:

1. Last Arrow Manufacturing has 12 cobots. In one example, using a cobot took production time from 75 min. down to 24 min. "Automation has been a key to reducing our overhead because everybody wants a price reduction, but health insurance, workers' comp, all those things are just continually increasing with no help in sight on any of that." —Matt Bowling, president, Last Arrow Manufacturing
2. "A little programming hack: Always use new consumables and check your Tool Center Point beforehand. I also program a few welds and run those welds just in case there's any distortion, or anything that's moving, just to verify programming."—Marvin Hererra, CWI, CWE, welding engineer, Freedman Seating Company.
3. "Cobots with modular fixturing tables work well. We have a team and machine shop dedicated to making fixtures. Notice we designed this fixture on a large plate with locating holes, so if we want to weld a different part, we quickly take off one fixture and put another on."—Marvin Hererra, CWI, CWE, welding engineer, Freedman Seating Company.
4. "We use the cobot not just for welding, but to tack up the components if we created a fixture where the threadolet [pipe fitting] was held in place. We can come in there and apply our sacrificial bridge tack. This also helps with distortion control because those things are predictable. An interesting conversation that we've been having is, why not have a cobot upstream from a traditional cell where now you're not doing so much hard fixturing?" —Corey Mays, CWI, president, CM Welding and Machine, Inc.

Welding experts can learn from their peers. Networking and conference opportunities, such as the Welding Automation Expo & Conference, can be a good place to start. *Courtesy Freedman Seating Company*

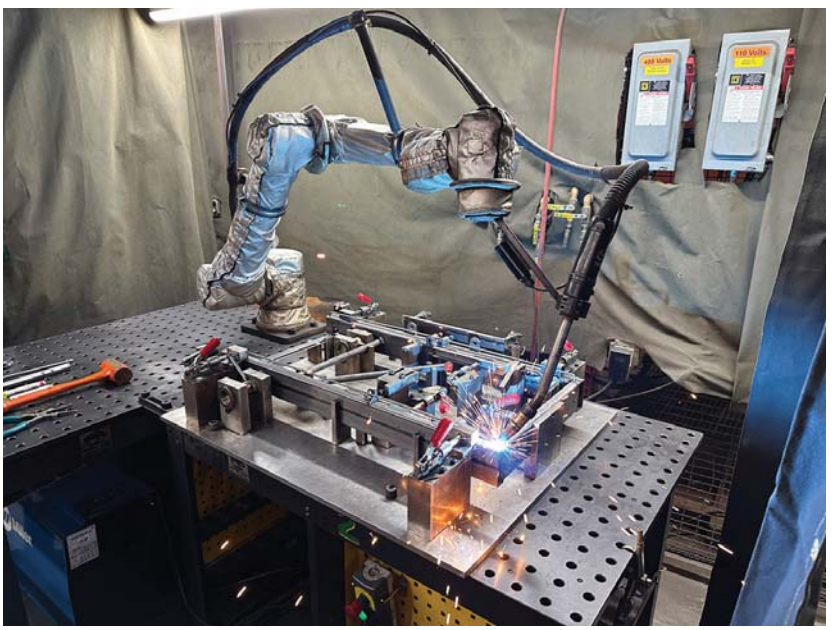
5. A presenter from Vermeer, a global manufacturer of industrial and agricultural machines, shared lessons related to implementing collaborative robots. They noted that successful implementation is all about messaging. They built a collaborative environment where employees had buy-in to automation and were part of that automation process so they would understand that automating isn't about replacing jobs; it's about being competitive in a market. The second lesson shared was not just to invest in new technology, but also to invest in people, which is part of the Vermeer philosophy.
6. Three keys to successful automation include ownership (especially for programming), line balancing (so you don't just move a bottleneck) and creativity. "Creativity can be found when people are equipped to succeed and then allowed the time to do it. Very few people are going to be instantaneously creative and successful in continuously high-pressure situations."—Joseph Russell, senior manager of Welding Engineering and Continuous Improvement, Arcosa
7. "What makes the Precision Power Laser (PPL) process different is that instead of using a very focused beam, we're widening up the beam. We're super heating the wire so that by the time it enters the laser light, it flows right in, melts and solidifies almost instantly as soon as it exits the puddle. It is a very fast process and very smooth, with no arc. You want it to be kind of boring, smooth and very clean, right? It's not an exciting bright arc throwing spatter everywhere."—Elliott Ash, welding engineer – Laser Applications, Lincoln Electric
8. "I said get a pick-and-place robot. Let's improve our efficiencies. My boss laughed at me. He said, 'You're going to have to sell that to corporate.' To sell automation to your boss, use the DMAIC process: Define, Measure, Analyze, Improve and Control. This five-step process will solidify every automation sale."—Joe Wallace, welding engineer, Matheson Tri-Gas
9. "Understand what your part tolerances are, especially the sub-assemblies as they grow into full assemblies. Parts tolerance stack up can be a huge problem with automation. We also talked about repeatability versus accuracy. How difficult is it to achieve the required fit up tolerance? Do you end up with varying gaps to fill? These are the things you have to look at before you start down the automation path."—Doug Zoller, president and general manager, Cloos North America
10. Use industry conferences to your advantage; connect with industry colleagues and learn from the gurus. "Conferences are important because effectively applying automation combines multiple disciplines," says Robert Roth, president and CEO of RoMan Manufacturing and AWS interim executive director. "For example, you have presenters who

are robotics experts but not welding experts and presenters who are welding experts but not automation experts. Success requires a multidisciplinary effort, and the diversity of the conference attendees helps build a cohesiveness around the application." Furthermore, if you don't know the answer, or even the right question to ask, chances are the person who could help you is sitting across the conference table or standing in the exhibit hall.

Want to learn more about how automation, robots and cobots are being used in welding, fabricating, and manufacturing? Register to attend FABTECH 2024, being held in Orlando from Oct. 15-17, with automation being featured throughout over 800,000 square feet of exhibit space.

This article was submitted by Trish Fliss, senior content manager, AWS.

"A little programming hack: Always use new consumables and check your Tool Center Point beforehand."
—Marvin Hererra, CWI, welding engineer, Freedman Seating Co.



PICKING PRECISION

Advantages of Robotics in Agriculture

To address the challenges of harvesting strawberries—not enough labor, ripeness accuracy, pick quality and food safety—Harvest CROO Robotics has been designing and manufacturing a modern engineering marvel.

by Sharon Spielman, Technical Editor

WITH AN EVER-INCREASING GLOBAL POPULATION, the agricultural community can no longer rely on human-only cultivation and harvesting for the current and future demand for food. Machine harvesting has been commonplace in grain-based fields for decades, but the challenges of picking fruits and vegetables have their own unique set of challenges.

"The project is continuously driven because of the difficulty of finding harvesting labor," said Bob Pitzer, co-founder, CTO and engineering manager at Harvest CROO Robotics LLC. "Strawberries are one of the most labor-intensive crops, and if an automated way of harvesting them is not deployed soon, the berries will go back to being a luxury item unavailable to the majority of people."

To address these challenges, Harvest CROO is transforming agriculture with technological advancements, cultivating the way for increased efficiency and productivity. Along with funding from the strawberry growers in central Florida, the company has developed a 12.5-ton connected, integrated, automated robotic strawberry harvester. This I had to see, so I took a ride out to a Wish Farms grower, G&D Farms in Duette, Fla. There, Pitzer and his team were running tests on the pre-production robotic picker and graciously showed me around.

Bob Pitzer, co-founder, CTO and engineering manager at Harvest CROO Robotics LLC, posed for a picture during *Machine Design*'s visit to learn about the robotic strawberry harvester that is being developed. *All photos by Sharon Spielman*

An IOT Ag Solution in the (Literal) Field

In the expanse of commercial and organic strawberry fields, controlled factory automation met an expansive mobile system. "The whole harvester is an IOT device," said Pitzer, as he pointed to the slow-moving large rectangular vehicle off in the distance. Unlike traditional six-axis robots confined to specific tasks in controlled environments, the robotic harvester faces the complexities of delicate strawberry picking amidst the vibrations of a moving platform.

"The harvester needs to be fairly nimble to navigate existing fields," Pitzer said, explaining that the farms aim to use

(Left:) Unlike traditional six-axis robots confined to specific tasks in controlled environments, the robotic harvester faces the complexities of delicate strawberry picking amidst the vibrations of a moving platform.

(Below:) The harvester must operate within the confines of the existing truck pathways on the farm for navigation.

their land efficiently by maximizing plant coverage; therefore, a large machine must operate within the confines of the existing truck pathways on the farm for navigation. "The harvester is four-wheel steer/drive to accomplish this and can spin on its wheelbase of 20 feet," he said.

Designed with efficiency and maintenance in mind, the machine operates on a diesel-electric setup akin to a train locomotive, with a large generator powering electrical motors for smoother, maintenance-free operation, Pitzer explained as we walked alongside the huge harvester. He said that for a machine intended to run 24/7, the choice of electricity over hydraulics ensures reliability and cost-effectiveness in the long run.

The heart of the robotic picker lies in its meticulously designed control system. Pitzer explained that the air cylinders are used to neutrally float the pick deck, which supports the weight of the 16 robotic arms and keeps them durable and robust. The balancing systems, including spring setups on the robots and mechanical adjustments, ensure precise positioning and reduce strain on the servo motors. Pitzer says that by incorporating spring balancing and other mechanisms, the machine optimizes energy usage and reduces heat buildup in the electrical components.

The machine's cooling system, which is reminiscent of refrigerator trucks, plays an important role in ensuring the freshness and cleanliness of the harvested strawberries, Pitzer says, noting that the harvester can hold up to 10,000 lb. of picked berries. A chiller system cools the fluid circulating through the tanks, which is necessary for sterilizing the berries and maintaining food safety standards. Unlike human labor, robots eliminate the risk of disease transfer and ensure a higher level of cleanliness by using quick disconnect parts that can be easily replaced and sanitized. This meticulous approach to handling berries not only reduces the chances of contamination but also spoilage.

The integration of advanced technologies like sensors and artificial intelligence (AI) enhances the performance of these robots in selective harvesting, where delicate fruits are carefully picked without damaging surrounding produce.

Robotic Pickers: From Concept to Fruition

The journey of conceptualizing and implementing these robotic pickers dates to 2013, Pitzer said, when the initial experiments were conducted. Harvest CROO, a sister company to the farm, spearheaded this endeavor funded by major players in the strawberry industry. Through years of research and development, the team has secured multiple patents for their innovative systems, establishing a new standard in agricultural automation. The robots' ability to scan plants, create 3D models and navigate precise paths for picking displays the level of technological sophistication that has been achieved in this field.

The data collection and analysis capabilities of these robotic pickers are vast with servers storing terabytes of information for real-time monitoring and decision making, according to Pitzer. The software integrated into the system enables farmers to track harvest progress, analyze crop performance and optimize harvesting strategies. Utilizing cutting-edge technologies like AI and cloud computing, these robotic pickers have transformed traditional farming practices by enhancing efficiency precision and data-driven insights.

The harvester uses LiDAR technology and differential global positioning systems (DGPS) to do all its navigation. "The GPS provides the waypoints and plant locations and the LiDAR detects the anomalies and farm accessories to be able to navigate the harvester around autonomously," Pitzer explained. "It's not fast, so collision avoidance and the pre-configured farm make navigation relatively simple compared to autonomous cars, etc.," he said.

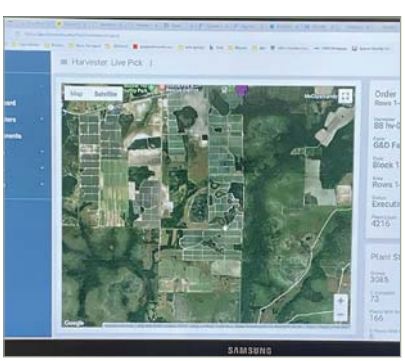
Using advanced cameras, LiDAR and electric actuators, the robotic harvester can scan, inspect and pick strawberries autonomously. As for the integration of sensors, AI and other technologies used to detect and harvest the ripe berries, Pitzer says the robots and inspection systems also use limited AI and

machine vision to pick and inspect the berries, all with RGB cameras. "The robots are positioned to look for the berries in a confined envelope to make the berries easier to find and provide conservation of motion for doing the pick-and-place for pulling the berries off the plants in an economical fashion," he said. "Ripeness is done in a proprietary way, and all the hardware is custom to handle the delicate fruit."

Over an 11-year span, the project has seen technological advancements and strategic partnerships with manufacturers, inching closer to producing harvesters at a viable rate, Pitzer said. By leveraging a combination of Intel Mobius and NVIDIA processors for vision processing and partnering with Festo for component fabrication, the project integrates cutting-edge technology and modular design principles to streamline production processes. "[The system] is cross correlating two cameras to tell you the depth of the strawberry,"—even with all the green that surrounds the plant, measuring the fruit bed within a couple of millimeters, Pitzer said. "We don't damage [the plant]…you couldn't do that on a single-processor system [before]," noting that much more powerful processors are being developed every day.

Cultivating a Business Plan, Nurturing the Future

To deploy thousands of harvesters effectively and work with farms that are accustomed to traditional labor practices, a strong infrastructure is necessary, Pitzer said. This collaborative effort not only ensures scalability but the goal is to foster partnerships with industry stakeholders (think John Deere and Caterpillar). Pitzer adds that the business model of leasing the machines to farms offers a sustainable approach to introducing robotic harvesters.



The harvester uses LiDAR technology and differential global positioning systems (DGPS) to do all its navigation and enables the harvester to be tracked in real time.

The team is able to capture and monitor all aspects of the harvester and its cultivating process using its dashboard—from how many berries were picked by each robot to whether or not the berry was ripe enough to pick or if there was even an attempt to pick.

The machine is in its testing and refinement phase, using data collection and feedback to improve performance. The harvester knows all the plant positions, so that gives it the ability to collect information about individual plants, Pitzer explains. "Many metrics are collected related to berries on the plant and any forecast information that can be accomplished like counting blooms or counting unripe berries. It is a large data collection machine," he said. "This information is constantly analyzed to improve robot performance and is going to be used in the near future for reinforcement training of the robot movement to improve."

As for how Pitzer foresees the role of robotics technology evolving in the agricultural industry: Manipulating robotics will first impact fresh fruits and vegetables. "Most people don't realize that 90% of what they pull out of the produce section of the grocery is still hand-picked," he said.

Some crops make more sense than others do initially because of the way they have to be harvested, Pitzer explained. "Strawberry plants are picked ~40 times during a growing season and account for 50% to 60% of the overall farm cost for growing the strawberries," he said. "It's a very expensive crop to harvest, therefore the cost of the automation can be justified. As this technology matures, it will reduce in cost and make sense to migrate to other crops."

From Challenging Competition to Agricultural Problem-Solving

During *Machine Design's* visit to G&D Farm, Pitzer also spoke about the FIRST Robotics Challenge, and specifically the impact it has had on endeavors such as the robotic strawberry harvester that the company and the strawberry industry has been designing and manufacturing for more than a decade. The competition has helped foster young talent in engineering and innovation, he said.

Originating in 1994, the FIRST Challenge involves teams constructing large robots to compete in various tasks. Behind the scenes, mentors and professionals focus on integrating lights, wires, software and infrastructure to ensure smooth event operations, allowing students to highlight their robot designs effectively.

Pitzer talked about the pivotal development that surfaced in 2009 when advancements were made to enhance robot capabilities through Wi-Fi control systems, challenging conventional beliefs about real-time control using Ethernet and Wi-Fi. Collaboration with industry leaders like National Instruments and Cisco drove the integration of networked robots, he said, setting the stage for students to engage in practical engineering tasks. The growth of the first robotics challenge, from 600 teams in 2006 to more than 8,000 teams today, underlines the impact of technology and mentorship in nurturing the next generation of innovative engineers and problem-solvers. ■

Optimizing Pick-and-place with **Cartesian Robots**

To fully understand the advantages, compare and contrast Cartesian robots with other six-axis articulated robots.

by Eric Rice, Festo Corporation

MOVING AN OBJECT from one location to another—picking and placing—is an ideal application for industrial robots due to the robots' repeatability, throughput and favorable return on investment.

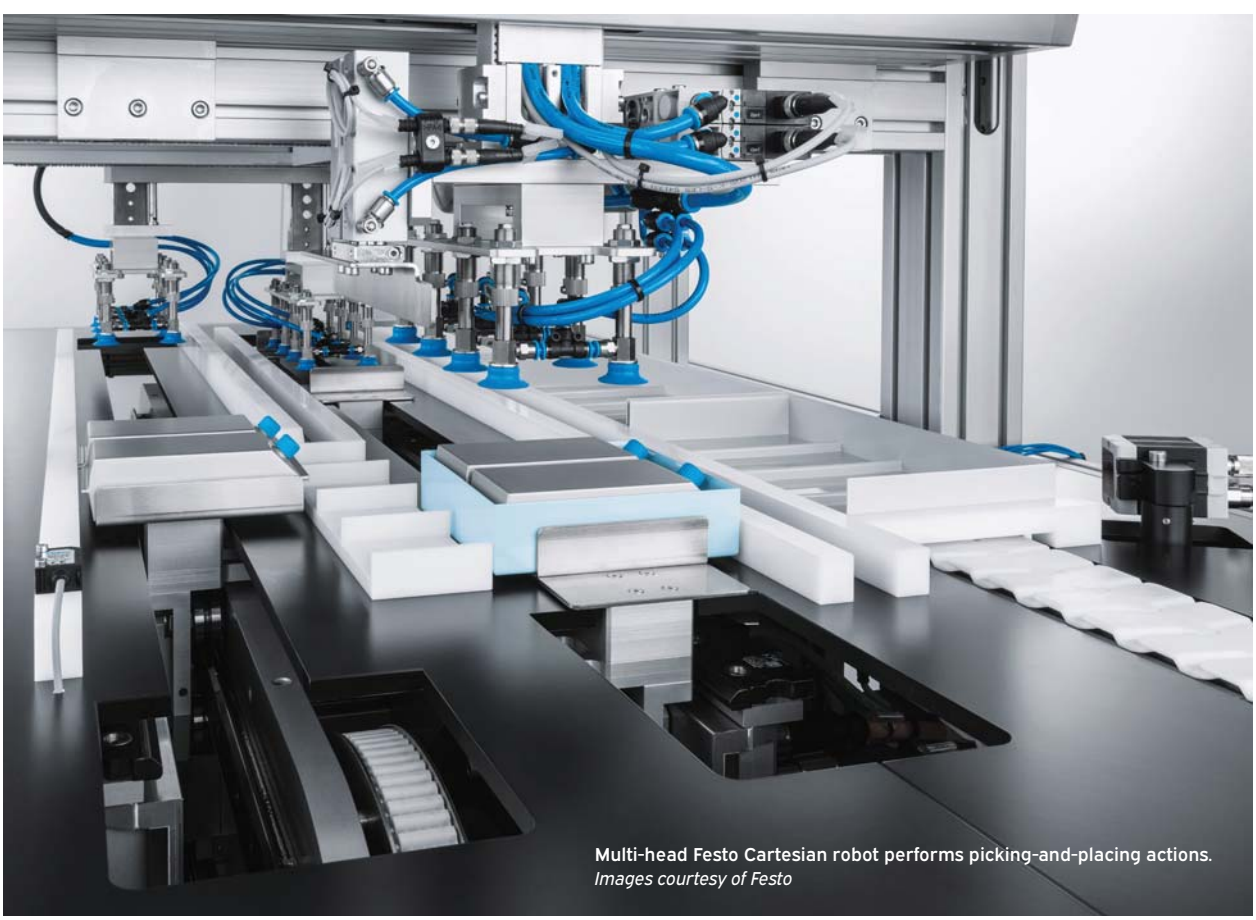
It is hard to imagine modern automated systems from on-machine pick-and-place to palletizing without industrial robots removing these repetitive tasks from the hands of humans.

360 Market Updates projects that the estimated $2.7 billion pick-and-place robotic market of 2023 will increase to $5.8 billion by 2031, a compound annual growth rate (CAGR) of 16.5%. Meticulous Research is even more bullish by predicting robotic pick-and-place at a 23.9% CAGR 2023 to 2030.

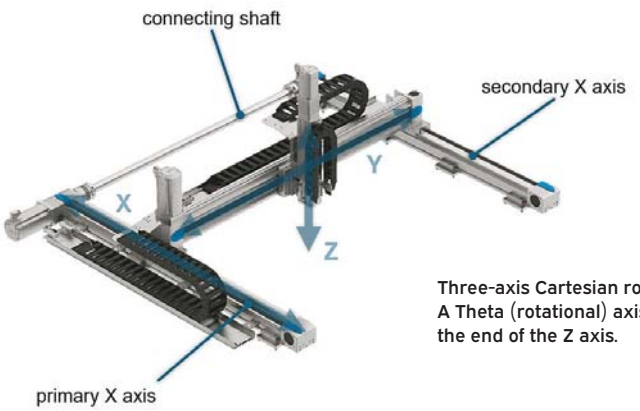
This article explores pick-and-place and the role that Cartesian robots play in these applications. Part 1 describes the unique characteristics of Cartesian robots. Part 2 compares Cartesians with six-axis articulated robots, including cobots, SCARA and Delta robots in pick-and-place applications. Part 3 wraps up with the best use cases for Cartesians.

Part 1: What is a Cartesian Robot?

Cartesian robots are linear robots because the principal axes for control are linear as opposed to rotary. Three axes mounted at right angles are often referred to as a handling system, multi-axis handling system or gantry robot. Each axis is



Multi-head Festo Cartesian robot performs picking-and-placing actions.
Images courtesy of Festo



Three-axis Cartesian robot: X, Y and Z axes. A Theta (rotational) axis can be mounted at the end of the Z axis.

driven by a servomotor. When there are two X axes as shown in the below image, one axis is the primary and the other is the secondary. The primary and secondary axes are often coupled with a rigid connecting rod, though in smaller systems the Y axis itself may mechanically couple the two X axes together.

Each axis has a cable management system with energy chain and tracks that hold the chain in place. There are adjustable mounts making sure the X axes are mounted flat and parallel on the machine. Rotary motion (clockwise or counterclockwise) is provided by a servomotor and rotary module mounted on the Z axis. Suction cup and gripper end-of-arm tools are the same as those found on any robot for pick-and-place. A notable feature of Cartesian robots is that they deliver consistent precision, capacity and speed across the entire workspace.

Part 2: Comparison of Industrial Robots

A common pick-and-place application involves moving items from one conveyor to the next. Because the Cartesian robot and the Delta robot are located above the workspace, the two conveyors can be side by side. The conveyors must be separated for the articulated and SCARA robots to accommodate their bases. The articulated robot's potential area of motion extends beyond the workspace, and that is why articulated robots require guarding. Cobots offer a circular workspace without guarding when operated in safe mode and with guarding when not.

As shown in the illustration above, the Cartesian robot workspace is a rectangular box with X, Y and Z dimensions. The Cartesian robot can pick-and-place everywhere within the box. An articulated six-axis robot's workspace is circular,

Comparison summary

	cartesian	articulated	SCARA	delta
Workspace	Rectangular / box No dead zones	Essentially spherical With dead zones	Kidney to cylinder shaped With dead zones	Cylinder or dome shaped No dead zones
Reach	Up to 8,500 mm	Up to 9,366 mm	Up to 2,200 mm	Up to 1,600 mm
DoF	3 to 4	4 to 6+	3 to 4	3 to 4
Payload	Up to 250 kg	Up to 2,300 kg	Up to 20 kg	Up to 12 kg
Product selection	Built-to-fit	Discrete sizes	Discrete sizes	Discrete sizes
Installation	Requires dedicated machine frame	Floor or table	Floor or table	Requires dedicated machine frame
Commissioning	Dedicated controller or existing PLC (drives only)	Dedicated controller, teach pendant	Dedicated controller, teach pendant	Dedicated controller, teach pendant
Key feature	**Optimized**	**Flexible**	**Economical**	**Fast**

Key points of comparison for Cartesian, articulated, SCARA and Delta robots in pick-and-place.

with a dead zone in the middle near the base where the robot cannot reach or do any work. SCARA robots offer a kidney-shaped workspace, and if they can reach behind themselves, more of a circular space with a similar dead zone near the base. Delta robot's workspace is circular with no dead zone.

Reach Within the Workspace

If the reach required within the workspace is up to 5.2 ft (1.6 m), all four robot types can accommodate that reach. If the workspace reach extends beyond 7 ft (2.1 m), then only Cartesian or articulated robots can be applied. If the application requires picking on one level and placing at another level, then all four can accommodate a level difference of 2 ft (.6 m). If the distance exceeds 5 ft (1.5 m), then Cartesian and articulated need to be applied. If the need is picking and then placing at a 90 deg. angle, the articulated robot can perform this action out of the box. The other three require special end-of-arm tooling. For any angle greater than 90 deg. only the articulated robot can accommodate.

Payload

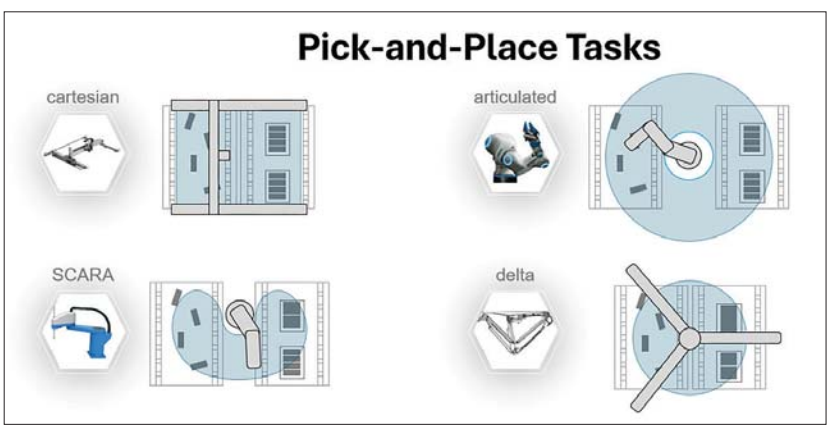
Payload is calculated by the mass of the tooling plus the mass of the workpiece. Delta robots can accommodate on average up to a 26 lb (12 kg) payload. SCARA can accommodate a payload on average up to 44 lb (20 kg), while cobots typically top out (although this is changing all the time) at up to 77 lb (35 kg). Cartesians can go up to 551 lb (250 kg), and the largest articulated, at the time of this writing, up to 5,000 lb (2,300 kg).

Articulated, SCARA and Delta robots are sold in discrete sizes. The design engineer may find that the payload of a model is ideal, but the reach or speed is not sufficient. The recourse is to buy a larger unit that has more capacity than needed. Discrete sizes often result in excess capacity, size and cost.

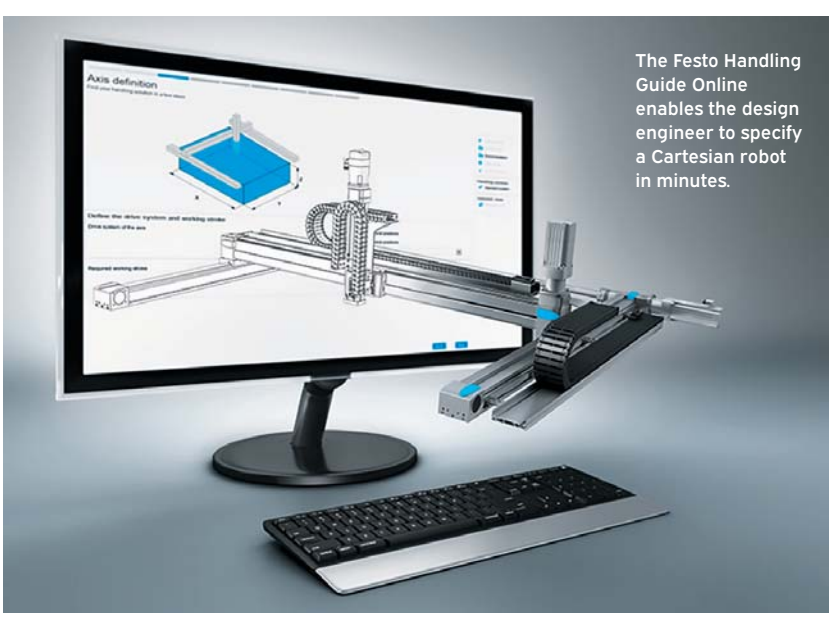
On the other hand, Cartesian systems are built to fit the requirement. Each axis in terms of length, load and speed is individually specified. The machine builder does not purchase excess capacity. This means that the pick-and-place can have a small workspace with a heavy payload or the same workspace with a light payload. There are online productivity tools from suppliers that allow an engineer to design a perfectly sized Cartesian robot in a matter of minutes using only application parameters. The robot arrives as a ready-to-assemble kit.

The SCARA's key feature is economical. If the pick-and-place can be accomplished with a SCARA robot, then it is probably going to be the least expensive option. SCARA robots are good at precise, high-speed picking and placing of small parts.

Delta robots are fast. If the workspace is small, the parts light and the action required quick, then a Delta robot may be the best choice. Typically, Delta robots are the most expensive. Make sure the requirement requires the high throughput of a Delta robot.



Each type of robot has a uniquely shaped workspace.



The Festo Handling Guide Online enables the design engineer to specify a Cartesian robot in minutes.

Part 3: Best Use Cases of Where, When and Why to Use a Cartesian Robot

Cartesians are built to fit. When there are custom lengths for each axis, the Cartesian will provide the right capacity.

It is impossible for a Cartesian to move out of its workspace so guarding is often unnecessary. No guarding, or limited guarding, reduces footprint and cost as

Best use cases for cartesian robots

- Long reach or custom stroke lengths in different directions
- Light to heavy payloads
- No reduction in repeatability or speed at full stroke
- Space constrained applications or where floor/table space is at a premium
- To save money
- Wherever an optimized fit is required or beneficial, such as repeat machine builds

well as making installation easier. Because payloads can be light to heavy, Cartesians can be applied in high-speed, small-parts pick-and-place as well as in heavy-duty palletizing for an extended range of applications. With a Cartesian, there is uniform speed, capacity and accuracy within the entire workspace. Cartesian robots are ideal for space-constrained applications where floor or table space is at a premium. Machine builders can generally find room above or to the side to use a Cartesian for pick-and-place.

Because they are mounted above the workspace, the Cartesian and Delta robots must be built on a dedicated machine frame specified to the dimensions of the robot. Articulated and SCARA robots will fit on the floor or table. Larger articulated robots will need to have structural features added for mounting.

Commissioning is another way that Cartesian robots differ. Every articulated, SCARA and Delta robot comes with a robot controller. Buy three robots, for example, and the machine builder receives three controllers. Cartesian systems can also be built with a controller, but because of their ability to move linearly without sophisticated kinematics, they can be operated with the existing PLC or an off-the-shelf PLC with motion capability. This means the entire machine code can be inside one controller with no separate controller or software license for that controller.

One Word Sums up Each Robot

If there were only one word to sum up each solution, the word for Cartesian systems would be optimized. Optimized goes back to built to fit—built exactly to the footprint of the machine. The capacity is exactly what is needed. The size of the individual actuators has been set according to the payload needed.

The key feature of the articulated robot is flexible—flexible not only in terms of range of motion but also in repurposing. If one needs an articulated robot with the appropriate reach, payload, and motion profile for a deployment that lasts a few months or years and then has a new need for a robot with a similar capacity, the asset can be redeployed.

In applications where either an articulated robot or a Cartesian can perform the pick-and-place activity, often the Cartesian will be the lower-cost option. Whenever an optimized fit is required or beneficial, such as in a serial machine, Cartesians are almost always worth a look.

When asked to envision industrial robots, most people in the manufacturing field visualize banks of industrial six-axis robots in automotive plants welding, painting or fitting decks or doors. And with the rise of cobots, the image of articulated robots grows stronger. The predisposition to applying articulated robots when robotics are needed can lead to purchasing more than necessary.

"Sometimes a customer will call with the assumption they need a six-axis robot," a robot integrator said to this writer. "After getting their requirements, we advise them to use a SCARA or a Cartesian robot because it will be a better fit." ■

Reconstructing Robotics for Modern Day Healthcare

Next-generation machines will integrate technologies to ensure proper functionality and patient safety. A holding brake—or, more specifically, an electromagnetic brake—is one of these technologies. Let's learn about this critical component of robotics systems.

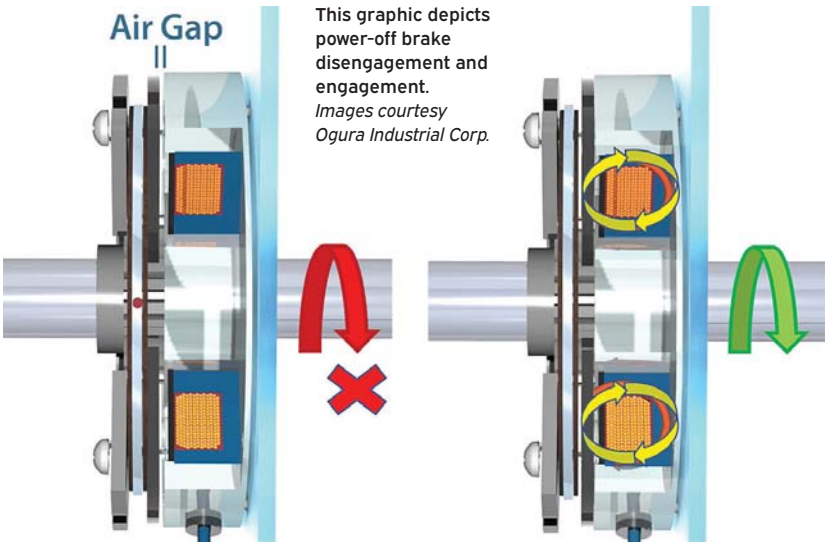
by Craig Harvey, Regional Sales Manager, Ogura Industrial Corp.

AS TECHNOLOGY CONTINUES TO eclipse previous achievements at a pace which seems to happen at an almost singular level, the field of robotics has shown unparalleled opportunities for seemingly endless possibility. When you pair the need for improved medical outcomes and consistent patient care with the ingenuity of the designers behind robotics, you find a niche like no other.

In the United States alone, healthcare spending exceeds $4.5 trillion per year and the costs are only rising. Companies are working to develop the next-generation of robotics platforms that will bring healthcare into a place where the cost-benefit matrix will be mutually beneficial for both patients and healthcare providers alike.

These next-generation machines will require integrating a multitude of technologies to ensure not only proper functionality, but patient safety as well. One of these technologies is used for precision positioning or holding as well as safety redundancy, and is commonly referred to as a holding brake—or more specifically, an electromagnetic brake.

Electromagnetic spring-applied brakes are devices installed on a shaft via a hub that operate using electric voltage to generate magnetic flux to counteract a mechanical spring force which is used to create torque when power is removed from the system. Power-off brakes are disengaged—meaning the shaft is free to



This graphic depicts power-off brake disengagement and engagement. *Images courtesy Ogura Industrial Corp.*

In the United States alone, healthcare spending exceeds $4.5 trillion per year and the costs are only rising. Companies are working to develop the next-generation of robotics platforms that will bring healthcare into a place where the cost-benefit matrix will be mutually beneficial for both patients and healthcare providers alike.

rotate—by applying power to the coil and are engaged mechanically via springs when power is removed from the system, allowing the brake to hold the load in place.

Using this fundamental design principle, there are many different variations available based on the application and the need to solve a specific challenge. For example, standard spring engaged brakes are the most common, have multiple coil voltages available and can be designed/manufactured in sizes as small as 8 mm in diameter.

Permanent magnet brakes, on the other hand, utilize independent permanent magnets to counteract and oppose the magnet flux generated when power is supplied to the coil of the brake. Both the permanent magnets and the coil generate their own magnetic fields, so providing electric voltage to the coil will determine the brake's engagement: No voltage to the coil means the brake is engaged and the shaft will not rotate; voltage to the coil means the brake will be disengaged and the shaft will be free to move.

This power-off brake has an 8 mm outer diameter and is shown next to a dime for size comparison.

Because the permanent magnets have such a high holding force, this type of brake has a high torque-to-size ratio as compared to a standard spring-engaged brake, meaning it can be small but powerful at the same time with very low backlash (more on this in a minute).

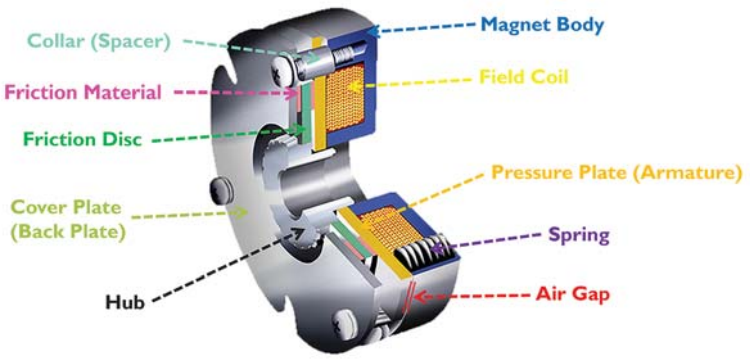
Understanding How Brake Components Operate Within Robotics Systems

Now that we have a baseline understanding of how some of the critical components within these robotics systems operate, let's look at where we would find some of the brakes we discussed. It would be difficult to not open with surgical robotics as this field has experienced the most exciting growth within healthcare since the first entirely robotic assisted surgery (RAS) was performed back in 1992. You will find power-off brakes located in multiple positions, from the wheels in the base to the overhead arms, all the way to the manipulators in arms or grippers at the tips.

Permanent magnet brakes, like the one shown here, use independent permanent magnets to counteract and oppose the magnet flux generated when power is supplied to the coil of the brake.

These brakes can commonly be found on the back of a motor in a sealed system, providing holding torque and an emergency stop function in case of a system-wide power loss. The opportunities within the medical field are quite vast, however, and do not stop within the operating room.

CT scanners and X-ray machines will both have brakes needed to hold and position the patient on a bed, as well as hold the imaging sensors in position during the scan or in the case of a portable system the scanning equipment itself. Hospital or emergency room beds that require multi-axis positioning also have a need for brakes to act as a back-up to



By using special friction discs and hubs along with customized brake architecture, backlash can be effectively eliminated altogether from the system, as shown in this diagram of a power-off spring engaged brake.

Thin profile and low power consumption power-off spring-engaged brake, like the Ogura RNB-T series, uses PWM technology to fit in smaller package sizes and allow for solutions to previous size restraints.

prevent the motor from back driving and to keep the bed from falling back to the horizontal plane.

Motorized medical mobility wheelchairs also have electromagnetic brakes installed as a braking system; this is a necessity to properly slow down, stop, and park the wheelchair from moving when in use.

Eliminating Robotics Backlash

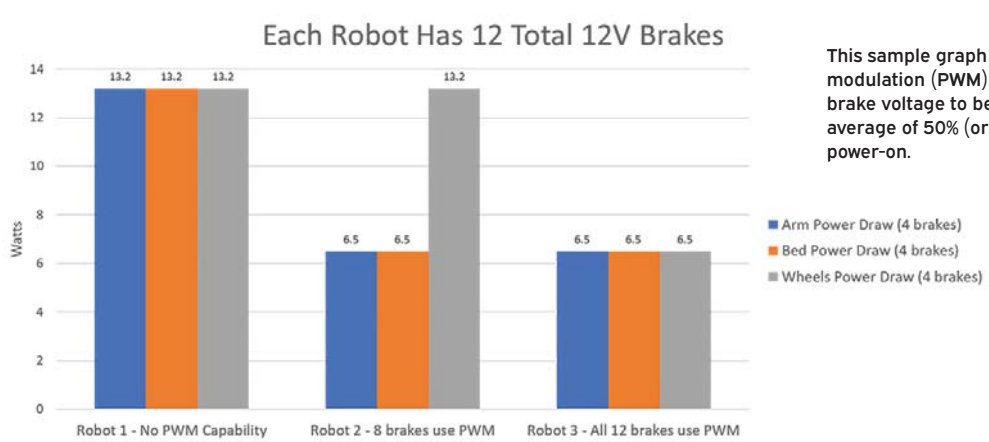
When an industry continues to innovate, it forces those around it to follow suit, and thus there have been several innovations in power-off brakes that go hand-in-hand with medical robotics. For example, backlash is a common concern in robotics and the ability to find a way to eliminate it is often a struggle when multiple systems are working in parallel. Backlash in this case is defined as the amount the shaft can still rotate when the brake is fully engaged.

Axial backlash can also be a concern. As you can imagine, while performing robotic assisted surgery, you do not want any "wiggle" while you work. Due to this, advances have been made to eliminate backlash in the two main problem areas: between the hub/friction disc and the interface between the armature/spacers. By using special friction discs and hubs along with customized brake architecture, backlash can be effectively eliminated altogether from the system.

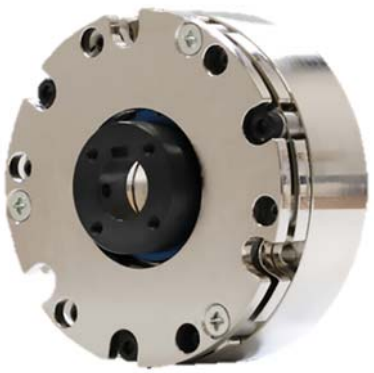
Using PWM to Ease Brake Power Consumption

Another large area of concern is power consumption. When you think of all the electronics that go into the development of a robotic system, the power draw adds up quickly, and pretty soon it's a very big number. To relieve some of that power consumption on the brake side, pulse width modulation (PWM) capabilities have been introduced, which allows the brake voltage to be stepped down an average of 50% (or more) after initial power-on.

For example, a brake using 24 VDC could have its power reduced by 50% by modulating down to 12 VDC, effectively cutting the wattage of the brake in half. This may not sound like much, but imagine having a few dozen brakes in one system; the power savings add up very quickly. Reducing power consumption will also reduce heat generation, which is generally a favorable outcome for the overall system as well. The earlier-mentioned permanent brake technology has



This sample graph shows how pulse width modulation (PWM) capabilities allow the brake voltage to be stepped down an average of 50% (or more) after initial power-on.



Spring-applied power-off brake like the MCNB-Z series pictured is designed for zero backlash and incorporates noise-dampening technology.

Power-off Brakes	Multiple Coil Voltages Available?	Zero Backlash Standard?	PWM Available?	Thin Axial Profile Available?	Controllable Torque?	Low Noise Design Available?	Large OD to ID Ratio Available?	Highest Torque-to-Size Ratio?
Yes	✓		✓	✓		✓	✓	
No		✓			✓			✓

Permanent Magnet Brakes	Multiple Coil Voltages Available?	Zero Backlash Standard?	PWM Available?	Thin Axial Profile Available?	Controllable Torque?	Low Noise Design Available?	Large OD to ID Ratio Available?	Highest Torque-to-Size Ratio?
Yes		✓			✓			✓
No	✓		✓	✓		✓	✓	

This chart shows a typical comparison of spring engaged vs. permanent magnet brakes.

an incredible torque-to-size ratio, but it cannot be used with a PWM circuit as it needs a specific voltage operating band for proper function.

The Benefits of a Thinner Profile, Reduced Noise

PWM technology led directly to the ability to produce brakes that have a much thinner profile than ever before, meaning they can be designed to fit in smaller package sizes for more creative solutions to previous size restraints. This style brake can often be found in the joints of a robotic system where axial space is the most critical.

Another popular position is in the wheel motors on the base of the robotic system. The weight of some of these systems requires motorized assistance to move them. Motors in the wheelbase have brakes installed, as well, so as to function as a holding mechanism (and in some cases an emergency brake). Space is very limited, so having a smaller profile is essential.

In some areas of the hospital—e.g., in an operating room—low noise is also very important. Brakes for applications in these areas needed to be developed to function with noise decibel levels acceptable for those environments. By using sound-dampening devices integrated into machined surfaces of the brake itself, the engagement sound of the brake (a metal clicking sound) can be substantially reduced to a more tolerable level and sound.

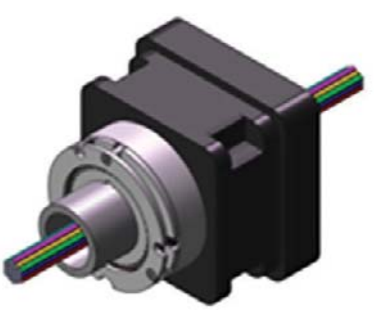
This style of joint product development comes with working hand-in-hand with those directly familiar with the environment the products would be used in, and is often the critical feedback needed during the product design stages.

Modern spring-applied brake designs have low inertia for rotating components. More specifically, the brake friction discs are exceptionally lightweight and have low inertia. This allows for improved responsiveness from the motor, lower power consumption, smaller designs and longer motor life. By having smaller motors on complex systems, the benefits start to multiply all the way back to the largest joint on a robotic platform.

Because brakes are very commonly installed with a motor on many of these robotic systems, it was only a matter of time before a large bore brake was necessary. These brakes are great for hollow bore actuator systems as wires from the robot can be run right through the brake and to the power source, making it easier to run all the necessary cables without the need for special pathways. Large hollow bore shafted motors are becoming more popular as systems become more compact and designers look for more creative solutions to run all the feedback, system and power cables.

As the industry continues to evolve, the need for engineered solutions will also trend in the same direction. Customized brake products to solve specific application challenges are a viable option and can be a faster solution if teams are engaged early in the design phase of a new program.

To reiterate, patient safety and improved patient outcomes are a huge indicator of success in the medical field, and we can see that even the smallest components in the system are key ingredients to overall success. While the electromagnetic brakes of the system may not be the most well-known part of the system, they are certainly one of the most critical. ■



Large bore power-off brake and large bore brake installed on a hollow shaft motor allows wires from the robot to be run right through the brake and to the power source without the need for special pathways.

Assessing the Technical Feasibility of **Implementing an AMR System**

Unlock the potential of autonomous mobile robots in today's industrial operations with expert insights from two MiR subject matter experts.

by Sharon Spielman, Technical Editor

INTEGRATING AUTONOMOUS MOBILE ROBOT (AMR) systems into a facility presents the opportunity to streamline industrial operations. The successful implementation of such advanced technology, however, hinges on a complete assessment of technical considerations to ensure a seamless deployment.

Drawing insights from our education series with interviews conducted with Rishabh Aurora, team lead for application engineering, and Tim Ideker, applications engineer, both at Mobile Industrial Robots (MiR), *Machine Design* was able to uncover considerations and strategies essential for the integration and scalable deployment of AMRs in modern workplaces.

Kashiyama Industries, a Japanese manufacturer specializing in the production of dry vacuum pumps essential for semiconductor and liquid crystal panel manufacturing, is using AMRs to enhance efficiency and address challenges in its production processes.

By tapping into their expertise, we gain perspective on the nuances of AMR technology adoption from selecting the right robots and optimizing plant layouts to addressing challenges that help ensure safety compliance and maximizing return on investment. Aurora's and Ideker's input shed light on the dynamics of incorporating automation into operational workflows and providing a comprehensive guide to leveraging the potential of AMRs in facilities.

Know Payload Requirements, Plant Routes

The foundation of a successful AMR system lies in the selection of the right robot tailored to specific payload requirements as well as plant layout for route planning.

Factors such as payload size, weight capacity and the need for specialized modules like pallet lifts or cart manipulators must be fully evaluated to optimize operational efficiency. To maximize productivity, it's important to choose the appropriate robot that can handle the designated tasks.

Effective plant layout design and route planning help ensure smooth navigation for AMRs within a facility. Assessing the availability of space, identifying obstacle-free pathways and establishing optimal travel routes can help with overall operational agility.

(Left:) Runner (automated its internal transportation and material handling through XIAMEN) Corp., a player in China's kitchen and sanitary ware industry, has a fleet of 12 AMRs, helping to create accurate, efficient and labor-free logistics processes.

By selecting the right robot and strategically designing the layout and routes, businesses can optimize efficiency, minimize downtime and maximize the productivity of their AMR fleet.

Integration with Existing Systems, Employees

Integrating AMRs with pre-existing warehouse management or enterprise resource planning (ERP) systems is important for the cohesive functioning of the operational ecosystem. Conducting compatibility tests, establishing systematic integration protocols and ensuring data synchronization between different systems are aspects to consider during the implementation process. A well-integrated system enables real-time data exchange, as well.

The interaction between operators and AMRs also plays a role in the smooth operation of the automated system. Implementing user-friendly interfaces, intuitive control panels and clear communication channels facilitate effective coordination between human workers and autonomous robots. Providing training on how to interact with AMRs and addressing any communication challenges can optimize workflow efficiency and ensure collaboration.

Clearly defining the roles and responsibilities of personnel involved in the implementation process is necessary to establish accountability and promote efficient operations. From operators responsible for overseeing daily tasks to maintenance staff tasked with system upkeep, assigning clear roles ensures smooth coordination and effective task allocation.

Connectivity, Environmental and Software Considerations

Reliable connectivity is a requirement for maintaining uninterrupted communication between AMRs and the central fleet management system. By ensuring a stable communication network and creating a conducive environment for AMR operations, businesses can enhance the reliability and performance of their automated systems.

Assessing environmental factors such as floor conditions, localization objects and temperature control also must be considered for sustaining operational efficiency and minimizing potential disruptions.

The selection of sensors, both onboard and external, coupled with software integration, can aid in the functionality and adaptability of AMR systems. Advanced sensors enable precise navigation, object detection and obstacle avoidance, while integrated software solutions provide real-time data analytics and decision-making support.

PoC Testing, Risk Assessment, Safety Compliance

Evaluating the integration of AMRs with existing infrastructures and workflows is necessary to transition to an automated operational model. Conducting compatibility checks, addressing navigation challenges and performing proof of concept (PoC) tests ensure that the AMR system integrates with the existing environment. This can help minimize potential disruptions and optimize performance.

Employees at Kinrise Snackfood in Australia have named their robots after their Cobs popcorn brand, including Wow, Choc, Ding and Pop! *Images courtesy Mobile Industrial Robots (MiR)*

Risk assessment and safety compliance adhering to established safety standards, conducting comprehensive risk assessments and implementing systematic safety protocols are imperative to ensure a secure operational environment for AMRs.

Prioritizing safety measures such as emergency staff mechanisms, sensor-based collision avoidance systems and regular maintenance checks minimizes the risk of accidents and enhances overall safety of AMR deployment. By emphasizing safety compliance and risk management practices, organizations can create a secure working environment and boost employee confidence working alongside autonomous robots.

Return on Investment Analysis

Determining the return on investment (ROI) for an AMR implementation involves evaluating a range of factors, including labor redeployment efficiency, operational cost savings and safety benefits. Calculating the tangible and intangible benefits of deploying AMRs such as increased productivity, reduced cycle times and enhanced workplace safety enables businesses to assess the long-term value proposition of automation. By quantifying the impact of AMRs on key performance indicators and financial metrics, organizations can make informed decisions regarding investment in autonomous technologies and measure the effectiveness of their implementation strategy. ■

For more AMR insights from MiR, be sure to check out our three-part video series at machinedesign.com/55036667.

Automate 2024 Wrap-up: Shifting the Robotics Paradigm to Flexible, Agnostic Solutions

Functional success of robotic and control solutions is tied to available information, flexibility and software upgrades. Heads-up: AI is integral to the mix.

by Rehana Begg, Editor-in-Chief

TO THE UNINITIATED, the number of AI use cases on display at Automate 2024 might signal a bonanza is currently underway. This year's trade show floor and conference agenda had use cases aplenty.

Compelling generative AI tools (the kind of AI that can create something new based on training data) were presented by vendors such as Nvidia—to extend capabilities in shop floor predictive monitoring, visual object inspection, work cell design validation and 3D perception for mobile robots—and Apera AI—to showcase AI for vision-guided robotic applications in the automotive industry.

The growing relevance of generative AI was borne out in a recent Deloitte survey, which reported that a majority (79%) of respondents expected Gen AI to drive substantial organizational transformation in less than three years. The survey also noted a strong focus on tactical benefits such as improving efficiency and cost reduction, as opposed to growth and improving innovation.

At Automate, a profusion of vendors lent credence to these data points by showing in manifest ways how the surge in smart factory technologies over the years has driven companies to use information more efficiently. An observable trend is the market interest in integrated robot control, which has generated a runway for different market players—machine builders, integrators, robot manufacturers and automation system suppliers—to get in on the benefits.

Siemens Industrial Copilot is the first generative artificial intelligence assistant for engineering in an industrial environment. Connected to the Totally Integrated Automation (TIA) Portal, the copilot enables users to find the right help topic and to generate a basic visualization and code faster for programmable logic controllers (PLC). *Siemens*

Although the smart automation landscape is changing quickly, much remains to be developed before the industry can provide the assurance of technology that is both predictable and stable. To be sure, not all use cases are created equal, and we cannot hold it against the discerning engineer's eye-rolling response (no matter how impolite it seems) to the prospecting borderline examples.

Rest assured, however, by the time Automate 2025 comes around (May 12-15, 2025 in Detroit), there'll be more innovations and new opportunities to roll with.

First Generative AI Product for Engineering

Count Siemens among vendors that are significantly further along their digital enterprise journeys than others. During a keynote session, the company touted its generative AI-powered assistant. This product, known as the Siemens Industrial Copilot, was first rolled out earlier this year at Hannover Messe 2024 and Siemens is now introducing it to its global markets.

Connected to the plant via the Totally Integrated Automation (TIA) Portal, the copilot enables teams to find a given topic and to generate a basic visualization and code faster for programmable logic controllers (PLCs). The copilot functions to reduce workloads, take on repetitive tasks and reduce errors when engineering complex tasks. The overall benefit is a boost in quality and productivity over the long term, noted Siemens. The Siemens Industrial Copilot for TIA Portal Engineering will be available for download in July 2024.

Bringing IT Workflows to OT Environments

Siemens also introduced its on-premises OT device, Siemens Simatic Automation Workstation, which was designed in response to the ubiquitous challenge of managing multiple hardware control points across the factory. Siemens noted that devices like PLCs require extensive programming to maintain currency and security. Thus, Siemens' industrial edge solution replaces a hardware PLC, a conventional HMI (human machine interface) and an edge device with a single, software-based workstation that can be managed from a central point.

"Centralized management is the best option for increasing visibility and security for manufacturers managing a high number of automation control points," said Del Costy, president and managing director of Siemens Digital Industries, U.S. "This makes automation highly scalable and changes the game for how factories can be managed."

Collaboration Brings Reliability to Pick and Place Logistics

An exclusive booth tour with Ujjwal Kumar, group president, Teradyne Robotics (parent company to UR and MiR) provided *Machine Design* with insights into the company's recent collaboration with Nvidia in designing an inspection solution capable of achieving path planning 50-80× faster than current solutions. "With AI we are trying to [marshal] an autonomous way to do inspection with a lot more variability and in an unstructured environment," Kumar said. "This is a great marriage of UR's core hardware with our PolyScope X operating system, combined with Nvidia's hardware and the AI software. It solves a very important problem for the industrial world around autonomous inspection."

A partnership between Siemens, Universal Robots and Zivid is another example reinforcing the shift whereby companies demonstrate at tradeshows how they collaborate with solution partners. These partnerships enable companies of all sizes to offer sustainable solutions while allowing them to scale.

In this case, the three partners harnessed three separate solutions to streamline warehouse automation and solve intra-logistics fulfillment tasks. The three solutions are:

- Siemens' Simatic Robot Pick AI, a pre-trained, deep learning-based vision software, developed for autonomous piece-picking robot applications, particularly in warehousing and e-commerce situations.
- Universal Robots' UR20 cobot, with 68.9 in. reach and 44-lb payload, enables automation of applications requiring the lifting of heavy objects over longer distances, while maintaining UR safety standards; and
- Zivid's 2+ M130 camera, the first 3D sensor capable of imaging everything, including transparent and translucent items, expanding the accessibility and pick ability for e-commerce and fulfillment applications.

UR, which shared a booth with Mobile Industrial Robots (MiR), also featured a joint offering of a mobile cobot (from Enabled Robotics) that could perform different tasks at different stations around the booth. Essentially, a UR cobot was mounted on the MiR250 AMR and affixed to the mobile cobot.

Seventh-Axis Robots Allow Technology Agnostic, Open Architecture

Best known for its pneumatic and electrical automation technology, Festo demonstrated its agnostic capability by integrating cobots from different manufacturers in a 7th axis application. The demo was targeted at integrators and machine builders, said Alejandro López, electric automation product manager, Festo.

Seventh-axis robots refer to robots on an electromechanical linear actuator that can move horizontally and vertically. The addition of a linear rail extends the reach of a six-axis robot.

Festo integrates cobots from different manufacturers in a 7th-axis application. Seventh-axis robots refer to robots on an electromechanical linear actuator moving horizontally, vertically or both. *Festo*

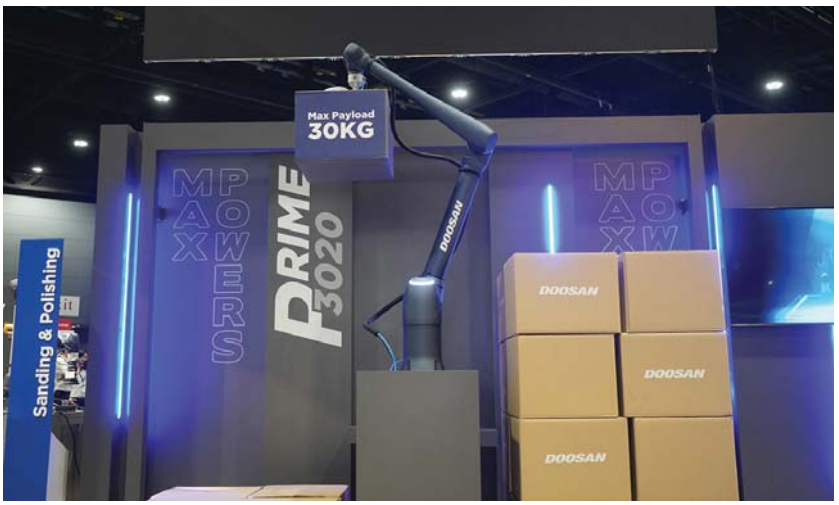
The productivity and cost advantages of moving the robot closer to the payload are appreciable. López explained that the use of smaller six-axis robots amounts to lower acquisition costs and a more compact footprint.

The demo also showcased a multi-axis system, the Festo Motion Control Package (FMCP), which is a complete motion control panel for up to four axes motion. It comes with panel control turntables, automatic storage systems, conveyors and transfer tables.

López was able to control the end-effector or gripper with a tablet. The VPPI actuated valve was controlled via analog signal and allowed López to adjust the pressure needed to handle delicate parts. The FDA-approved gripper can handle eggs and other food items, he said, as well as glass (including lightbulbs).

Advancing Cobot Capabilities Through AI-Driven Software

At the Doosan Robotics booth, attendees were likely entertained by a crowd-pleasing cobot drumming session or the "Mixmaster Moodie" demo. Either way, the company successfully signaled the potential leap AI applications can take.



Doosan also unveiled its P3020 cobot at the show. The cobot has a payload of 60 lb and can palletize up to two meters high without a lift. Doosan Robotics

"Mixmaster Moodie" is a bartending cobot powered by Microsoft's OpenAI. A Doosan cobot fitted with a soft robotic end-effector employs a pioneering cocktail recommendation system to serve a libation based on visual and audio cues.

Theatrics aside, South Korea-based Doosan Robotics proved its worth as a leading cobot manufacturer, with the company's share price soaring following its initial public filing in October 2023.

At the booth, attendees would have been introduced to Dart-Suite, an advanced platform that enhances cobot capabilities by integrating AI and making advanced technology available to an ecosystem. Alex Lee, president, Doosan Robotics Americas, characterized the platform as intuitive and easy to use. It operates like a smartphone, Lee said, and users simply download apps to unleash different functions within the platform. "It allows you to download third-party software into your control scheme with no programming whatsoever and you have the application up and running in minutes," Lee said.

For instance, one can download a palletizing application to a plug and play controller. "You won't need skilled individuals, that's what the cobot allows you to do," Lee said. "That's where the evolution is taking us."

Doosan also unveiled its P3020 cobot at the show. The cobot has a payload of 60 lb and can palletize up to two meters high without a lift. The rationale behind the development of the P-series cobot, Lee said, stems from the fact that many packaging companies using palletizing solutions found a limitation when it came to weight and reach. Designed to bridge the gap, the P3020 is a 30 kg cobot with a 2,030-millimeter reach. "It is the heaviest payload with the longest reach cobot in the market," Lee said. "Not only that, but it is also the fastest robot in the market within the collaborative space. The cobot is capable of rotating at 360 deg. in one second."

4D Vision Solutions and CAD-Powered AI Training

Apera AI is known for using 4D Vision as its underlying technology. The company characterizes the 4D process as follows: A scene is captured by 2D cameras before the images are run through proprietary AI technology. These images are integrated into a 3D rendering of the scene, where single objects are identified as pickable. Next, the robot chooses the most viable part. Path planning instructions are specified via Apera Vue software in the robot's controller.

Whereas conventional machine learning algorithms rely on CAD models for training, Apera AI uses synthetic data to train neural networks using CAD drawings or 3D scans. The cycle time is very fast—as little as 0.3 seconds (3 Hz). The object is picked and placed with precision. The automation solution is applicable in bin picking, sorting, packaging and assembly.

The company is further transforming robotic guidance. At Automate, Apera AI unveiled two offerings: Forge Lab and Foresight.

Forge Lab, a CAD-powered AI training and simulation solution, handles the vision programming by simulating the robotic cell. Since this is a web-based solution, users don't need a physical camera setup or robot to use the product. System integrators or in-house staff can use the app to complete proofs of concept in a matter of in hours. The process includes building out the cell by specifying the cameras, robot models, gripping strategies and pick points. The user can then test and refine the cell setup in a virtual environment. Next, the user uploads a CAD model of the part to the Forge engine for training. The program uses simulated data to refine the code that is to be deployed to the customer's Apera Vue vision software in the plant environment via the cloud.

The second offering, Foresight, is part of Apera AI's Vue robotic vision software and updates image processing by enabling the robot to come back to the working area already equipped with instructions on how to pick the next part. According to Apera AI's press note, Foresight processes 2D images "in a new way" through Vue's AI engine to create 3D object identification and path planning for industrial robots and cobots.

The time needed to locate, pick, move and drop a part is known as cycle time. The efficiencies gained from refining this motion, both at the point of the camera and the robot, are key to steps in engineering an optimized robotic sequence. Based on Apera AI's testing, Foresight can help decrease total robot cycle time by as much as 30%. ■

A Booth Visit with Yaskawa at Automate 2024:
Two Vision System Applications

Yaskawa featured a vision system that enabled fast, accurate robotic bin picking and robotic parcel induction work cell.

by Rehana Begg, Editor-in-Chief

AT AUTOMATE 2024, two demos at Yaskawa's booth—illustrating the importance of real-time vision systems and high-speed picking capabilities—drew *Machine Design's* attention.

Application No. 1: Parcel Induction and Simulation

In an order fulfilling demonstration, a six-axis Yaskawa GP12 robot is paired with a PickOne AI-powered induction software from Plus One Robotics. Random packages that are predefined or appear in random orientations move along a conveyor. The robot must latch onto the positions of the packages in real time and, without losing any speed, handle a wide variety of packages.

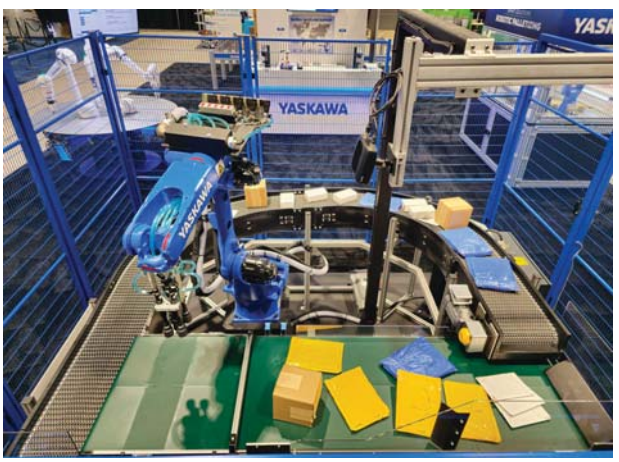
A variety of parcels are used to simulate what one might see in order fulfilling stations at a FedEx or UPS facility, according to Chris Caldwell, product manager at Yaskawa Motoman. Their businesses are high speed, but they also have a human in the loop," he said.

Speed is an important characteristic. The platform showed a pick rate of between 1,600 and 1,700 per hour for a variety of products in the cell. The AI-powered vision system enables 2D images of items, in addition to their 3D geometric surfaces, edges and corners.

Caldwell said the vision system can produce a pick for most items, but in the rare case that it doesn't, it fires off a "yonder call" to either a trained employee, or an off-site monitoring service. "Typically, one human can monitor between 10 and 20 cells and, within 30 seconds the employee will be able to interact with a call instructing the robot what to do and get that robot back up and running," said Caldwell.

Robots and automation have for a long time tended to be operated on predefined points, whereby they were programmed with hundreds or thousands of individual points. "That type of automation has reached its peak," said Caldwell.

The industry has seen growth in this specific application, according to Caldwell, especially with all parcel carriers, third-party logistics companies and e-commerce fulfillment centers.



Yaskawa

The benefit of the automated solution is that they can achieve very high pick rates each hour and need to set aside a small floorplan.

Application No. 2: Fast, Accurate Robotic Bin Picking

The demo featured a Keyence 3D vision system and relied on a predefined CAD model of the parts. An image sensor located above the cell projected light and detected objects contained in the bin.

"With their setup program, we load the robot model and end effector details," explained Caldwell. "It does all of the path planning and collision avoidance."

A very long gripper ensures the end effector can go deep into the bin and turn once inside, without running into edges. The robot distinguishes between objects (in this case, miniature toy robots) that have a very small difference and are programmed to be placed face up and face down. The robot meticulously selected parts and placed a set of robots face up on one tray and face down on a second tray.

Cycle time is a bit slower than the AI-powered induction, said Caldwell, but it addresses the key thing that people frequently look for: ease of use and setup. In addition, being able to pick deep into the bin, all the way to empty, is another feature when there are several thousand pieces of goods in a bin. The hardest parts to pick are the top 5% and the bottom 10%. "That's because you start running out of potential pics and you get into orientations and laying in a shadow up against the wall," said Caldwell. This solution, he said, picks until the bin is completely empty. ■

Automate's Product Spotlights: From Automation Essentials to Advanced Solutions

by **Sharon Spielman,** Technical Editor

THE FOLLOWING ROUNDUP highlights the range of solutions that were on display at Automate 2024.

From pneumatic and electric automation solutions to state-of-the-art safety protection such as automated doors and actuators, here is just a glimpse into the future of industrial automation.

Explore a range of products including pressure, vacuum and temperature transducers along with essential components like cylinders, switches, encoders and photodiodes. These products are shaping the way industry works and interacts with automated systems.

QUANTUM DEVICES PARTNERS WITH OEMs TO PROVIDE ENCODERS

Quantum Devices, a U.S.-based encoder manufacturer, designs and manufactures high quality, high performance incremental optical rotary encoders for a range of industries and applications. As seen at the Automate Show, the company partners with original equipment manufacturers (OEMs) to provide application-specific encoders for servo motors, robotics and many other applications. They can accommodate special design requests and deliver custom solutions that add value to equipment and automation systems. The company also manufactures custom photodiodes with either single or multiple diode structures on a single chip. This configuration is a p-on-n structure and can be used to detect the presence and absence of minute quantities of light. The linearity of this response can range over several orders of magnitude, from 10 picowatt/cm^2 to several hundred MW/cm^2.

QUANTUM DEVICES

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DYNATECT MANUFACTURING INC. OFFERS PROTECTIVE SOLUTIONS IN AUTOMATION

Dynatect provides protective solutions in automation—such as automated doors, clutches, cable carriers, manual doors, ball screws, bellows, roll-up doors and machine-door actuators—to leading manufacturers, integrators, distributors and consultants. Products and services specifically for the manufacturing, welding and metalworking sectors include automated barrier doors and machine safety doors; cable and hose carriers; door actuators for automating CNC machine doors; bellows, covers and machine roof covers; machine pit roll-up covers; ball screw repair; and way cover repair. The company's automated machine safety door (pictured) is designed to be an effective solution for increasing productivity and industrial safety. The high-speed door isolates hazardous operations from personnel, equipment and materials, but it allows for easy access when needed, minimizing cycle times to keep production lines running efficiently. Beyond its core function as a safety barrier, the AMSD can adapt to various automated processes, functioning as both a secure barrier and an industrial safety curtain. This automated machine door can be equipped with an optional LiDAR scanner, which senses an obstruction approaching the closing door and quickly stops the door to avoid impact, providing an additional layer of safety for workers and equipment.

DYNATECT

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CAMOZZI AUTOMATION SHOWCASED PNEUMATIC AND ELECTRIC AUTOMATION SOLUTIONS

At Automate 2024, **Camozzi Automation** showcased its latest innovations designed to help manufacturers optimize productivity, efficiency and safety across their operations. Camozzi offered attendees to explore pneumatic and electric automation solutions by demonstrating a comprehensive portfolio of products, including proportional technology, actuators, grippers and IIoT connectivity solutions. For applications that require linear and rotary movements, the company offers ISO or non-standardized actuators. All actuators have a modern design and are developed to save space and weight and can have different construction types to satisfy the most critical sectors. The company says it works on both the digitalization of production processes and the creation of real cyber-physical systems to enable the integration of mechanical, electronic and digital elements—constantly improving process performance.

CAMOZZI AUTOMATION

www.machinedesign.com/55055962

NASON'S SWITCHES, CYLINDERS AND TRANSDUCERS COME STANDARD OR CUSTOMIZED

Among a range of components that **Nason** had on display at its Automate 2024 booth were its CR series stainless steel pneumatic cylinders (pictured). Designed for smooth startup and operation, the cylinders are constructed with low-friction Nitrile seals and factory lubricated with FDA-complaint food-grade PTFE-impregnated grease, the stainless steel cylinders' precision-machined components and low-friction bearings ensure long life and effortless operation. The stainless steel in the CR Series is non-porous and resistant to corrosion, making them ideal for applications that require strict compliance to purity and quality standards, such as pharmaceutical and food preparation, or areas that need to stand up to punishing elements, like wash-down environments. The company offers automated assembly machines/systems, sensors and sensor integrated systems as well as design, engineering and support services.

NASON

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Ad Index

KHK OFFERS A MULTITUDE OF METRIC GEARS

Specializing in metric gearing, **KHK USA** has been producing its product line since 1935. Brian Dengel, gearing executive at KHK, showed us the metric gears for industrial automation applications at Automate 2024. There were rack and pinions in a range of lengths and pitch as well as spur, bevel and worm gears in an assortment of sizes and configurations on display. The gears are finished with polishing, tempering, surface processing, teeth shape measurement and examination with 3D measurement devices. The company offers free software for gear calculation and gear drafting. With a few known parameters, these programs can help design the best gear geometry for each unique application.

KHK

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The Evolution of Industry: What's to Come for Industry 5.0?

With manufacturing on the cusp of a new industrial epoch, a look backward can provide clues about what's in store.

by Micah Statler, Director of Industrial Technologies, Advanced Technology Services

SINCE THE INDUSTRIAL AGE began, manufacturing has undergone several transformative waves driven by technological advancements. From the mechanization of the first industrial revolution to the digitalization of Industry 4.0, each wave has reshaped production methods and revolutionized industries worldwide. Now, as we enter a new era, a paradigm shift toward collaborative human-machine interactions emerges, promising unprecedented changes.

A Brief Look into the Evolution of Industry

1. **Industry 1.0—Mechanization:** This era marked a revolutionary shift with the introduction of steam engines and water wheels, powering mechanized production processes. It laid the groundwork for factories and mass production, shaping modern manufacturing. The transition from manual labor to mechanized processes revolutionized industries, allowing for increased production capacity and standardized output.
2. **Industry 2.0—Electricity:** The advent of electricity heralded a new phase, characterized by widespread electrification and assembly lines. It boosted efficiency and productivity, fueling global industrial growth. Electricity enabled the development of large-scale manufacturing operations, leading to economies of scale and the production of goods on a mass scale.
3. **Industry 3.0—Automation:** Automation and computerization defined this era, driven by advancements in electronics. Programmable logic controllers (PLCs) and robotics transformed manufacturing processes, enhancing productivity along the way. The integration of automation technologies allowed for greater precision and consistency in manufacturing, thus reducing human error and increasing production speed.
4. **Industry 4.0—Digitalization:** Building upon previous revolutions, this phase embraced digitalization to create smart, interconnected factories. IoT and big data analytics enabled real-time monitoring and predictive maintenance. The adoption of digital technologies revolutionized production systems, enabling data-driven decision-making and the optimization of operational efficiency.

Understanding Industry 5.0

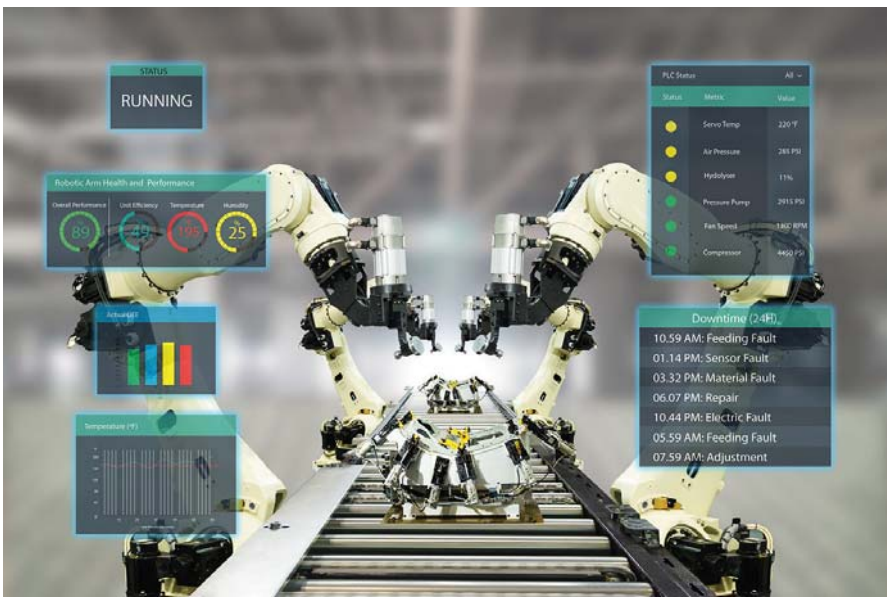
Industry 5.0 builds upon the achievements of Industry 4.0, while placing a heavy emphasis on societal value and well-being. It represents a shift toward a human-centric, sustainable and resilient approach to industry, focusing on prosperity beyond jobs and growth while respecting the planet's limits. By prioritizing the holistic well-being of workers and the environment, this new era aims to create a more inclusive and equitable future for all stakeholders involved in the manufacturing ecosystem.

Important Insights

- A collaborative nature. Industry 5.0 involves humans working alongside robots and smart machines, leveraging technologies such as IoT and big data for enhanced productivity and efficiency.
- Supporting humans in manufacturing. Industry 5.0 aims to support, not replace, humans in manufacturing. Recognizing the value of human intuition and problem-solving, it emphasizes collaboration between humans and machines to drive innovation and success.
- Balancing efficiency and productivity. While Industry 4.0 focused on efficiency, Industry 5.0 emphasizes refining collaborative interactions between humans and machines to optimize productivity and achieve sustainable growth.
- Inevitable progress of Industry 5.0. This shift represents the manufacturing world's event horizon, with advancements such as robotics and AI driving irreversible progress toward collaborative manufacturing for a brighter future.
- Addressing challenges and opportunities. Embracing Industry 5.0 requires addressing challenges like excessive automation while leveraging opportunities for optimal outcomes from human-machine interactions.

The Benefits of a More Collaborative Approach

Industry 5.0 represents a paradigm shift toward collaborative human-machine interactions. It embodies a symbiotic relationship between robotics, AI and human expertise, maximizing efficiency, creativity and innovation. This collaborative approach fosters a dynamic environment where humans and machines work together to achieve optimal results, shaping the future of industry.



As this collaborative ecosystem evolves, we'll see the integration of human intuition with machine precision generate breakthroughs in problem-solving and product development, as well as a host of other benefits. By leveraging the complementary strengths of both humans and machines, Industry 5.0 paves the way for unprecedented levels of productivity and advancement across various industrial sectors.

Employing Collaborative Robotics

At the core of this new era lies collaborative robotics, redefining the relationship between humans and machines. Collaborative robots—or cobots—seamlessly integrate into various tasks alongside humans, augmenting productivity while helping ensure safety. They are designed to adapt to dynamic environments, enhancing flexibility and scalability for a more agile workforce.

Augmenting Human Capabilities with AI

AI amplifies human capabilities and decision-making processes within Industry 5.0, playing a pivotal role in streamlining operations and boosting efficiency. Machine learning algorithms optimize processes, anticipate failures and propel innovation, ultimately fostering agility and responsiveness. By continuously learning from data and interactions, AI systems evolve to better support human workers and enhance overall performance, empowering individuals to achieve more in their roles and contribute to the success of their organizations.

Empowering Workers with Digital Tools

Industry 5.0 emphasizes fortifying workers through cutting-edge digital tools such as augmented reality (AR) glasses and exoskeletons. AR glasses enhance accuracy and efficiency, while exoskeletons reduce strain and injuries, fostering a culture of collaboration and well-being. These digital tools not only enhance individual performance but also promote knowledge sharing and skill development among workers, therefore driving continuous improvement in manufacturing processes.

Enhancing Connectivity and Data Insights Through IIoT Sensors

IIoT sensors offer real-time insights into production processes, enabling predictive maintenance and optimizing production schedules. They facilitate supply chain visibility, fueling informed decision-making for enhanced efficiency and competitiveness. With advancements in sensor technology, Industry 5.0 is poised to revolutionize data-driven manufacturing practices, promoting continuous improvement and modernization for sustainable growth.

Understanding the Implications Industry 5.0 Could Hold for Your Strategy

The concept of Industry 5.0 transcends traditional notions of "industry" and extends its influence across all sectors and organizations. Its scope is far broader than that of Industry 4.0, impacting every facet of business operations. Therefore, when considering its implications for strategy, it's imperative to adopt a comprehensive approach that encompasses all industries. As illustrated by the European Commission, Industry 5.0 revolves around three fundamental pillars: human-centricity, resilience and sustainability. These pillars profoundly shape business strategy, guiding organizations toward strategies that prioritize people, adaptability and environmental stewardship.

Embracing the Collaborative Future of Manufacturing

As Industry 5.0 unfolds, it represents more than just another phase in the evolution of manufacturing; it embodies a fundamental shift toward collaborative human-machine interactions. With a focus on societal value, well-being and sustainability, Industry 5.0 offers a vision of industry which goes beyond mere efficiency and productivity. By embracing the collaborative potential of humans and machines, manufacturers could unlock new levels of innovation and creativity while navigating challenges and opportunities in this dynamic era.

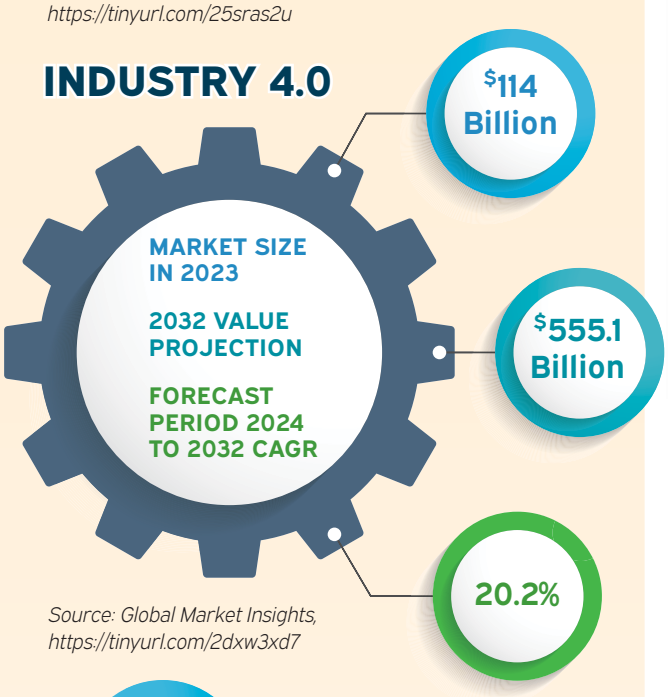
As we move forward, it's not merely a question of whether a business can benefit from this new paradigm, but how they might best leverage these advancements to drive optimal outcomes and shape the future of manufacturing. ■

THE NEXT REVOLUTION

THE TERM INDUSTRY 4.0 was first used publicly at Hannover Messe 2011. Ushering in the Fourth Industrial Revolution, it refers to smart innovations revolutionizing manufacturing and industrial processes. The concept Industry 5.0 was introduced by the European Commission in July 2020. Known as the techno-social revolution, Industry 5.0 shifts the paradigm of industrial systems design by emphasizing societal goals, including the well-being of industry workers. Researchers say the co-existence of the two revolutions invites questions. It also demands answers.

REFERENCES: https://tinyurl.com/2d3vzo47 and https://tinyurl.com/25sras2u

INDUSTRY 4.0



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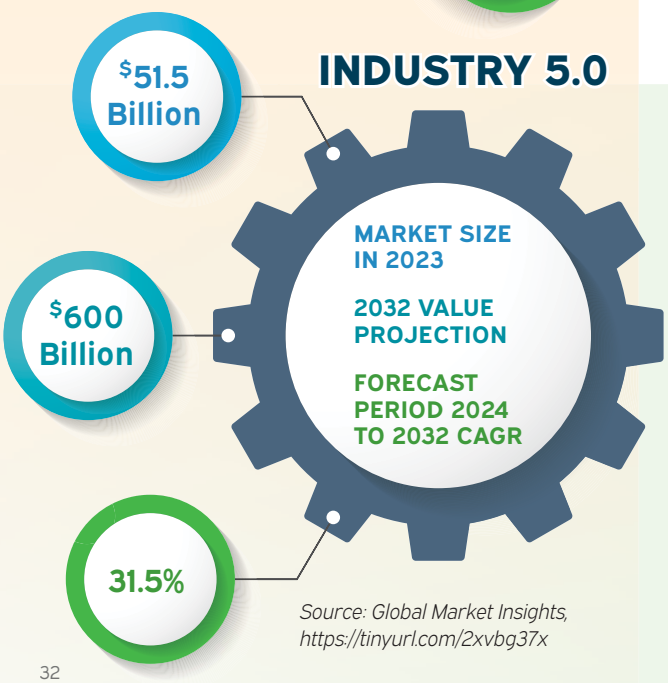
INDUSTRY 5.0



Source: Global Market Insights, https://tinyurl.com/2xvbg37x

WORD SEARCH, HIDDEN THEME

Find all the words in the list and then fill in the blanks with the unused letters beginning in the top left to reveal the hidden theme.

Find puzzle answers here: machinedesign.com/55127239

A	A	R	C	R	K	O	B	S	O	S	T	S	I	E	C
U	S	U	O	O	I	C	R	K	R	B	C	K	G	N	A
T	V	T	T	N	N	E	A	O	O	I	B	E	P	C	S
O	O	V	P	O	P	T	T	B	N	U	F	C	C	O	C
M	J	U	P	P	N	I	R	O	D	F	O	U	A	D	I
A	T	M	I	C	C	O	R	O	E	E	R	I	R	E	L
T	F	R	C	A	T	T	M	C	L	A	E	W	M	R	U
I	G	D	P	A	C	L	T	O	C	L	A	F	E	S	A
O	F	A	U	E	Q	O	U	Y	U	Y	E	M	L	X	R
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A	R	A	C	S	O	I	X	I	K	A	I	A	S	M	H
C	E	E	U	T	Q	R	T	S	O	F	T	W	A	R	E
I	M	H	I	M	A	N	I	P	U	L	A	T	O	R	X
M	V	O	V	I	S	I	O	N	A	R	T	U	A	B	E
Q	N	V	E	L	O	C	I	T	Y	H	J	Z	V	Y	L

accuracy	controller	HMI	SCARA
actuator	effectors	hydraulics	sensors
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