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Motion Control and Vision Advances Drive Collaborative Robot Applications

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EDITOR'S NOTE

Industrial automation is ideal for precise, repeatable tasks, but what happens when robots leave safety cages and bolted-down production lines? Advances in perception and motion control enable robots to work more closely with humans, be used in flexible ways, and deal with more complex, real-world environments.

In this Special Focus Issue, we look at numerous examples of how sensors, software, and motors have been combined to provide new levels of utility and collaboration for robot arms and mobile platforms.

From robots designed to see in 360 degrees to the ability to quickly understand an object's relative position and motion, learn how cameras, lidar, and machine vision can unlock new applications. Robots can increasingly operate in tight spaces and handle a widening range of items.

A range of sensors enables cobots to operate safely around human colleagues. E-commerce and agriculture are benefiting from these advances.

Perception and motion control aren't just enabling new applications; they're changing our relationship with machines.

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ADVANCES IN VISION SYSTEMS

Unlock New Cobot and Mobile Robot Capabilities

Vision systems are giving versatile robots more to see and do.

BY CESAREO CONTRERAS

DreamVu combines its Vision Intelligence Software with its camera systems. Source: DreamVu

Collaborative robots are often heralded for being safer alternatives to traditional industrial robot arms. It's well understood that cobots don't have to be caged into work cells and can work in proximity to humans.

That safety and the relative ease of programming are why collaborative robot arms continue to grow across a variety of applications, from food handling and palletizing to plasma cutting and piece picking.

But's what the story behind the sensors and underlying technologies that enable robots to perform their tasks safely alongside people? What advancements give these ro-

bots an even better understanding of the world around them?

PAL provides robots all-around vision

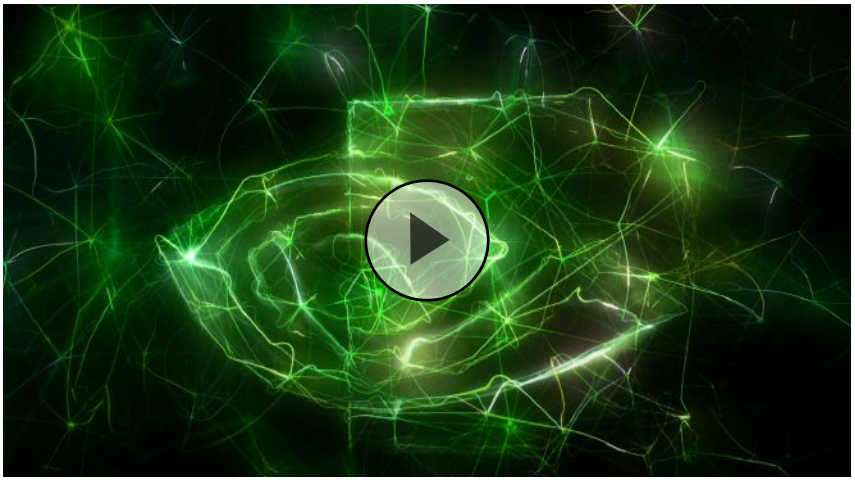
Philadelphia-based DreamVu makes omnidirectional 3D vision systems that give cobots and autonomous mobile robots (AMRs) the perception data for obstacle and human detection.

The company prides itself on being able to provide robots with 360 degrees of vision within a single-vision system. PAL products include the PAL Mini, which has a depth range of up to 3 m (9.8 ft.), and PAL USB and PAL Ethernet, which have depth ranges of 10 m (32.8 ft.). It also sells an omnidirectional vision system that provides 3D imaging up to 100m (328 ft.) called Alia.

"The reliable and efficient system has no moving parts, making it ideal for manufacturers and operators in robotics, factory and warehouse automation, and teleoperations where low latency and ease of use are critical," the company said in a product page describing the PAL USB.

The vision systems use NVIDIA's Jetson NX Carrier Board GPUs. Rajat Aggarwal, CEO of DreamVu, said NVIDIA's chips have helped the company take advantage of more sophisticated software to better take advantage of artificial intelligence.

Robots that can only take advantage of CPUs from Intel are more limited, power-wise, Aggarwal said. Those limitations can pose problems since a good vision system needs a robust amount of data to work well.



Photoneo combines two ToF, structured light technologies

Another important part of a vision system is its ability to take in light to analyze environments.

Photoneo says its patented "Parallel Structured Light" technology enables robots to accurately detect and understand objects in their environment even while they are in motion.

The Bratislava, Slovakia-based company said it created the technology by combining "the high speed of time-of-flight systems and accuracy of structured light systems."

"This unique snapshot system enables the construction of multiple virtual images within one exposure window – in parallel (as opposed to structured light's sequential capture), which allows the capture of moving objects in high resolution and accuracy and without motion artifacts," Photoneo wrote in a blog post.

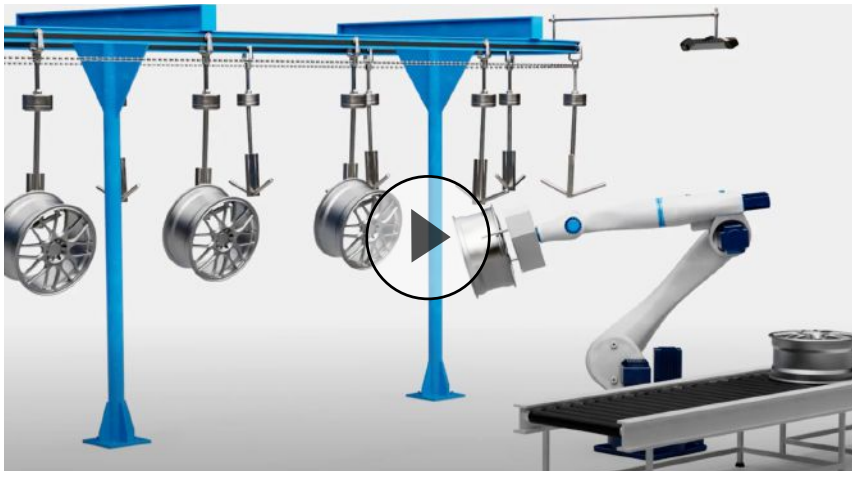
The company uses the Parallel Structed Light Model on MotionCam-3D, its line of 3D cameras. The cameras are capable of scanning scenes moving up to 144 kph (89.4 mph).

This technology enables robots to accomplish a greater number of applications, claimed the company. Photoneo mentioned the ability to scan animals, human body parts, and plants.

This summer, the company announced a color version of MotionCam-3D, which enables newer capabilities, including augmented and virtual reality (AR and VR) applications. Robots can now also do tasks that "require colorful 3D scans of dynamic scenes in perfect quality," said Andrea Pufflerova, a public relations specialist at Photoneo.

"A robot navigated by MotionCam-3D or MotionCam-3D Color does not need to stop as it continually receives a stream of 3D point clouds at high FPS," she added.

"The robot can react to sit-



uations and its changing environment in real time, which also eliminates the risk of collision," said Pufflerova. "This is extremely important in collaborative robotics where a robot works together with a human worker and where the robot's movements need to be 100% reliable and safe."

Maxon Motor makes drive systems designed for tight spaces

Motors also play an important role as they give robots the ability to move. Maxon Motor is building frameless motors and integrated drive systems to optimize precision and to give robots the power they need in confined spaces, according to Biren Patel, business development manager at Maxon USA.

He sees an increasing need for components to be of both low weight and size to accommodate for collaborative robots.

"With robots being integrated around humans, there will be a need for more sensors to be placed into tight spaces, and this will limit the space there is for motors and drive electronics," said Patel.

When developing its new ECF DT Series of motor products, Maxon focused on optimizing the torque-to-weight ratio as well as the torque-to-volume ratio, he noted.

"Maxon has developed various new compact encoders with high resolution, keeping in mind the space limitation and precision that is required from robotic actuators," Patel added. "Our ENX 16 RIO and ENX 22 EMT are some examples of compact encoders with high resolution."

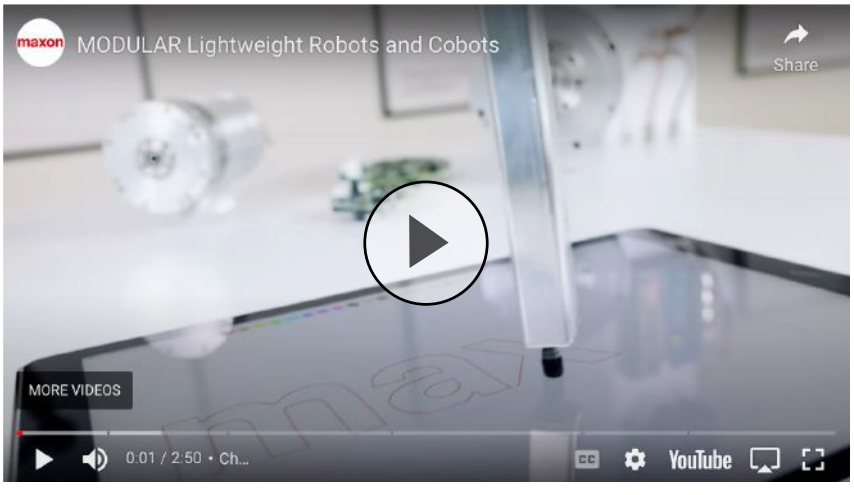
He also mentioned the company's off-axis encoders.

"They allow the end user to realize a solution with hollow-shaft drive trains," added Patel. "We are working on a cyclo-wave gearbox with no backlash which is critical in many robotic applications."

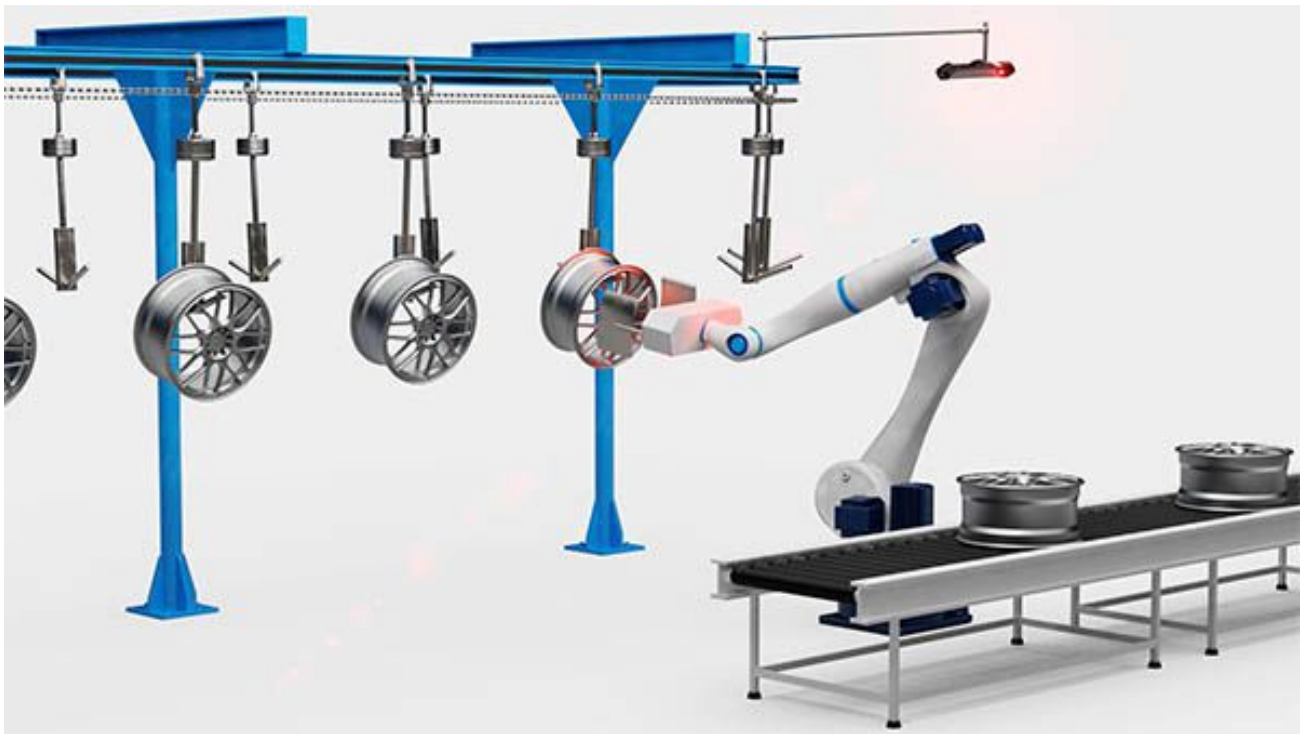
Patel mentioned how the company designed an integrated wheel system, which includes a gearbox, motor, brake, and controller, for its customers in the automated guided vehicle (AGV) market. Maxon has an option that includes the wheel itself, as well as options that don't.

In many cases, a customer's exact need may not fall in line with Maxon's preset catalog of products, he acknowledged. In those situations, Patel said the company works with them to find a solution that that fits its needs. "It's not one size fits all," he said. •

Cesareo Contreras *is associate editor at* Robotics 24/7.



Vision and Motion Control Drive Cobot Applications



Source: Photoneo

Innovations in 3D vision and motion controls have expanded what cobots are capable of accomplishing

BY TOM KEVAN

To increase collaborative robots, or cobots, capabilities and broaden their application range, robotics companies are leveraging advances in both vision and motion control systems. One of the most important recent developments in vision technology has been 3D vision.

"3D vision systems are becoming very easy to integrate into robot applications and provide much better information for a robotic application than a 2D vision system ever could," said David Bruce, manager of intelligent products & vision at FANUC America.

3D scanning gives cobots better perception

One advancement in vision systems that enhances cobot capabilities is 3D scanning in motion.

"Until recently, the majority of applications using collaborative robots and 3D vision have been limited to static scenes," said Frantisek Takac, a strategic partners manager at Photoneo. "To recognize an object, navigate to it, inspect it, and pick it, a robot must get the object's accurate 3D reconstruction, with exact X, Y, and Z coordinates that define the object's position."

"The new technology of parallel structured light is based on a unique sensor architecture that acquires the image in one snapshot, as opposed to the sequential scanning of a standard image sensor. This means that the parallel structured light method practically freezes the 3D scene in time," Takac added.

That enables the robots to see, he said, and gives them the capability to "manipulate objects in 3D space or evaluate their quality during manufacturing." That's a "big game changer," he added, because this can happen quickly and accurately.

Another development that helps to enhance vision precision is the inclusion of artificial intelligence (AI) tools in smart cameras.

"Recent innovations in smart cameras enable AI detection filters for part defects and inspection for glue beads, grease, and welds applied by the cobot itself," said Adrian Choy, product manager of robotics at Omron Automation America. "These features are often coupled with intuitive software wizards that accelerate the development of vision solutions."

Motion control ranges from motors to hand guidance

Advances in several areas of motion control are also helping cobots to take on more difficult and sophisticated applications.

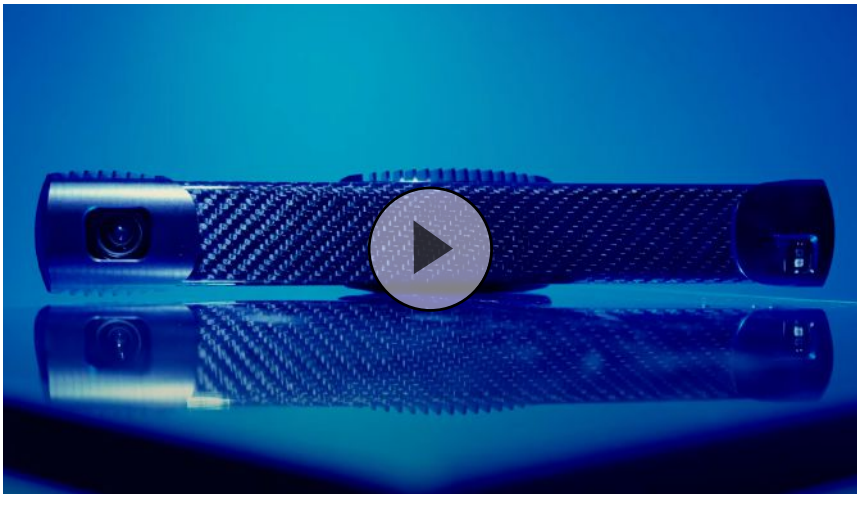
With increasing demand for greater, more efficient cobot mobility, motor manufacturers are challenged to meet market requirements for a higher torque density that pairs well with highly efficient, gearbox-like harmonic gearing.

"The improvements in motor designs have achieved higher torque density with advancements in the materials used and the manufacturing process in winding the motors," said Yoshi Umeno, global market manager for robotics at Kollmorgen.

"For instance, by optimizing the amount of motor materials, creating the power for the motor, and reducing the excess heat from the motor, Kollmorgen's TBM2G motor can deliver the performance to meet the market needs."

Motion control technology has also made significant strides in safety, allowing motion control devices to be integrated with cobots without adding unnecessary levels of risk.

"Omron's 1SA series servos can operate at configurable, safe, and limited speed and positions in instances where personnel need to approach a cobot workcell," said Choy. "For example, a cobot mounted on a vertical seven-axis lift, driven by a servo, can be programmed to move



slower or maintain safe heights to avoid striking humans when they approach the cobot."

Motion control has also seen intriguing developments in the programming and guidance of cobot movements. One groundbreaking advancement is real-time reconstruction of a cobot's immediate environment.

"Real-time reconstruction enables the cobot to react to situations in real-time without slowing down its operation, eliminating the risk of collision with its changing environment," said Takac. "This is especially important in applications where multiple cobots share the same workspace or where a cobot shares its workspace with a human worker."

Another advance in this area uses manual intervention to automate cobot movements.

"Hand Guidance is the ability of the operator to control cobot motion by guiding or leading the robot through the desired motions," said Greg Buell, product manager for collaborative robots at FANUC America. "This is both useful in teaching applications, where the path points or paths are recorded as the user guides the robot, and also in heavy lifting applications, where the process requires manual placement or movement of a large part with the smooth and gentle motion of a robotic arm."

A technique similar to hand guidance involves the programming of high-end controllers.

"Advanced controllers can now be programmed by teaching the environment first rather than teaching the mechanics of the pick-and-place," said Mike DeGrace, UR+ ecosystem manager at Universal Robots. "The motion controller and software then determine the path of the robot autonomously."

Cobots clean up heavy equipment production

A good example of how advanced motion control can open the door for an automation application can be seen in the introduction of cobots in a manufacturing operation.

Carriere Industrial Supply (CIS), a manufacturer of heavy equipment for harsh mining environments, deployed Universal Robots' UR10e industrial cobot to make the plasma-cutting process used to produce large metal

parts more efficient. Specifically, the goal of the initiative was to streamline the cutting process by reducing the extensive waste cleanup.

"Using a robotic arm, we knew that we would get a more precise cut and possibly eliminate all of the grinding and cleanup of the joints," said Pierre Levesque, manager of innovation and technologies at Carrier Industrial Supply.

Mason Fraser, junior software engineer at Carrier Industrial Supply, and his team leveraged the Java computer-vision library BoofCV, the MonkeyEngine 3D game-engine library, and a webcam to project and line up the metal part in space, allowing the operator to know exactly where to cut every time.

Once the team started cutting, they realized that none of the parts were formed perfectly off the brake press. To correct this flaw, they developed a way to maintain a consistent cutting height above the plate, using the UR10e built-in force/torque controller and the drag nozzle of the plasma-cutting torch to drag along the surface of the plate to maintain a consistent distance while cutting.

Unfortunately, the pressure generated by the torch caused the nozzle to bounce off the plate. To solve the issue, the team wrote a custom proportional–integral–derivative controller in UR script code, and used that to compensate for the torch height with voltage feedback. This allowed the robot to keep a steady distance off the plate for every cut.

CIS realized a significant time and cost savings using the cobot and motion control system. Previously, 80 percent of the plasma-cutting time was spent cleaning up the waste from the manual cuts.

On a single large truck body contract over the subsequent three years, Levesque determined that the trimming process on that project alone would be more than 50 hours for every truck.

Moving to a cobot application reduced that time to 12 hours per truck, ultimately saving 1,000 hours and realizing a significant cost savings on this project. •

Tom Kevan *is a freelance writer/editor specializing in engineering and communications technology.*

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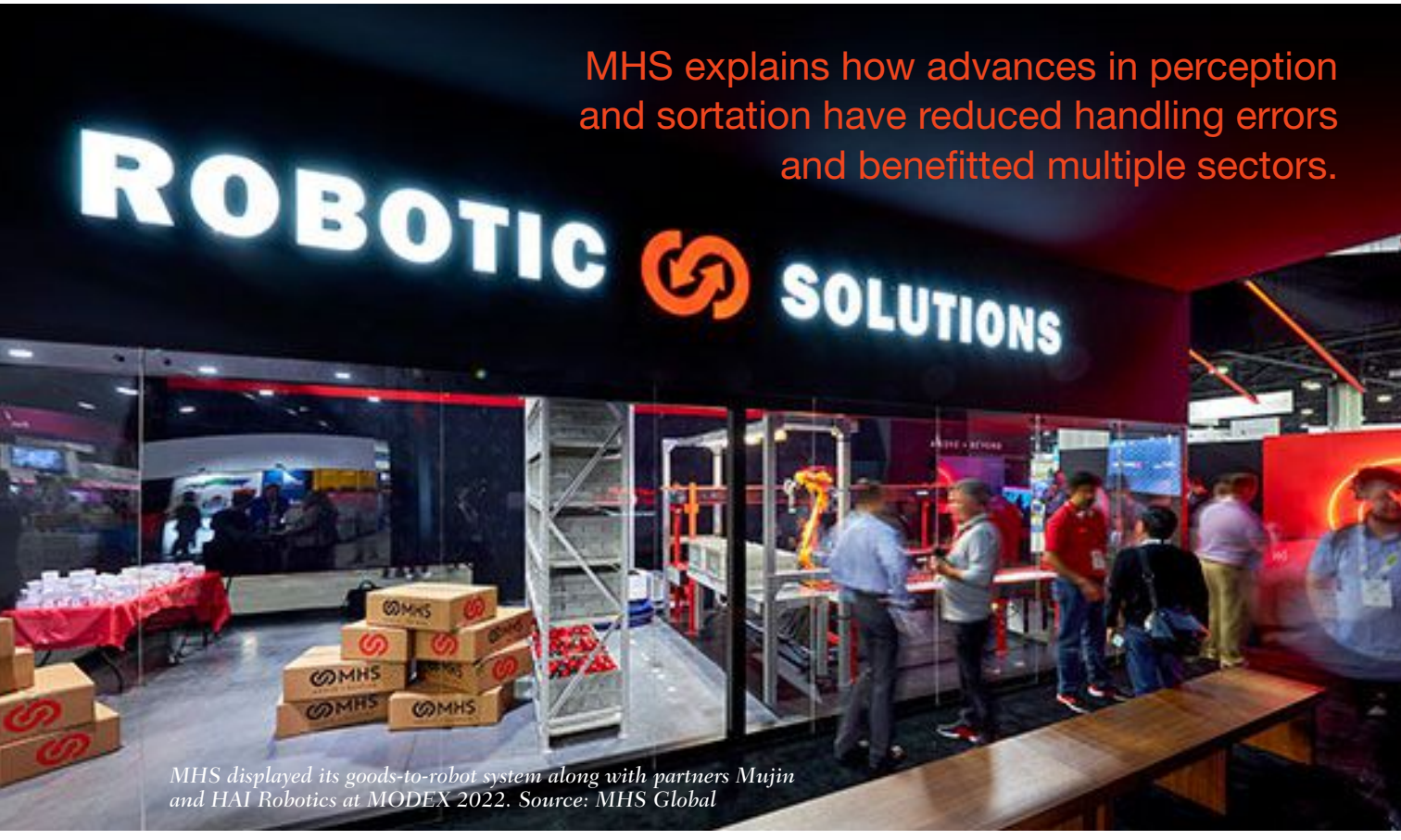
Picking Robots Gain Speed and Accuracy

BY EUGENE DEMAITRE

MHS explains how advances in perception and sortation have reduced handling errors and benefitted multiple sectors.



MHS displayed its goods-to-robot system along with partners Mujin and HAI Robotics at MODEX 2022. Source: MHS Global

While obstacle detection and avoidance have largely been solved for mobile robots, perception and manipulation remain challenging for piece-picking operations. Advances in computer vision, machine learning, and end-of-arm tooling are now enabling robots to pick at human and even superhuman rates.

One company focusing on successful automation of pick-and-place workflows is Material Handling Systems Inc. (MHS). The Mt. Washington, Ky.-based company spun out MHS Robotics from its research and development unit last year.

Kristiyan Georgiev, R&D manager for computer vision and software engineering at MHS, spoke with *Robotics 24/7* about improvements in robotic picking applications.

How long have you been at MHS, and how does your prior experience help you manage these technologies?

Georgiev: I joined MHS three years ago. My career has ranged from medical devices to high-frequency trading, and I've been at companies big and small, including startups.

Kristiyan Georgiev, MHS

The common theme among all these positions is tackling complex problems in difficult situations. The main difficulty in singulation of parcels using robots is that not every parcel is the same. There's no model that you can build to provide accuracy for all of them.

Robots must be able to handle items without having seen them before, operating on the fly. There are also corner cases, like a loose wire or a signal not getting to the sensor. You have to be able to question the premise of a new device and difficulties around it.

As for execution, I got my Ph.D. in autonomous ground vehicles and SLAM [simultaneous localization and mapping]. I focused on these features in my dissertation, then on things involving 2D vision and AI.

How much growth in demand has MHS seen from e-commerce acceleration in the past two years?

Georgiev: Quite a bit—we're experiencing 40% to 50% growth every year, and it was an even bigger number during the pandemic.

Which sectors can benefit most from newer automation—consumer packaged goods, pharmaceuticals, or something else?

Georgiev: Three core categories can benefit from these systems. The first is the cost of labor. Is the technology reducing the amount of labor required to operate?

Distribution and fulfillment centers are good candidates for automation because they're labor-intensive. As Amazon has been growing, the number of its employees has grown alongside that of robots because of the growth in online ordering.

The second is where there's a lack of qualified workers, such as in skilled trades for manufacturing. Robots are good candidates for repetitive tasks, such as welding, assembly, or machine tending. A CNC machine takes a block of metal and removes piece of it to achieve the desired shape. A robot can then take it out and put in a new block.

The third is where product quality or process efficiency matter. Pharmacies are good candidates for automation because it's not efficient for customers to wait to pick up their prescriptions. We'd love to have a machine do it. I've heard horror stories of incorrect medicines because of human error, where the customer didn't find out until afterwards.

How have MHS's picking systems improved over the past few years?

Georgiev: We've improved quite a few things in our robot singulator. Throughput has nearly doubled. We use the same exact robot and layout, but smarter software makes better decisions over time.

Another area is mis-sorts. The machine takes one package from a pile of packages and inducts it into a sorter. A single package has to be small enough to fit and oriented the right way.

Previously, we struggled with doing it 100% of the time and had errors. For example, the robot might take two packages, which is a problem for sorting. We reduced the number of errors by 10 times.

MHS's algorithm is now able to handle a wider variety of packages—including some not in specifications or what's expected. This includes large parcels and different textures, materials, shapes, prints, etc.

Speaking of edge cases or exceptions, how much are people still in the loop for robotic picking?

Georgiev: The amount of time between required interventions by humans are most important. Robots are not here to replace jobs but to complement workers. Humans are a lot more agile and can think outside the box.

If something not up to spec occurs—such as a large box or a torn one—humans can see it and take it out. Cases where you need a person include when there's trash on the conveyor belt or missing labels.

The rest of the time, you want robots to do the repetitive task of picking and placing individual packages. To reduce interventions, we've built better controls and communications for the robot to interface to other machines and the facility.

Which technology has changed the most—machine vision, machine learning, gripper technology, or motion control?

Georgiev: We've improved the software and can replace the physical robot arm, and they still perform the same tasks. We've deployed this at a few locations already.

By changing the layout and recognizing where there's a bottleneck—the camera confirms the pick of a single package. While there are physical limitations of speed, acceleration, and the robots' capacity, with two robot arms, we can increase the throughput.

We have deployments in four locations, including in one small contract and one large contract, with one to five very large contracts expected this year.

The vision software MHS has built in house has improved the most. We've transitioned from a hybrid approach relying more on neural networks to understand the scene and types of packages and make better decisions on how to pick them and how to orient end effectors.

Certain suction cups have better properties for picking loose polybags, and the system knows where to place it and the overall order of picking.

For the multi-pick end effector, what size or sorts of items are most commonly fulfilled? How does its throughput compare with current industry norms?

Georgiev: Our end effector ranges from small envelopes of 3x3 in. flat to bigger boxes of 20x20x20 in. We tell the robot where to pick and how to pick. It can dynamically configure the motion of the robot, depending on the object. We've observed different mail mixes. Some days, it's mostly polybags; others, mostly boxes. MHS tends to do better with boxes, which have a defined shape. Polybags might be perceived as oversized based on their shape—a human might just fold a polybag, but a robot might reject it.

We now have three years of data, comparing one robot shift with a shift of human operators. Humans are more dexterous and can handle short intervals, but intense activity is not sustainable. In the long run, robots do slightly better than people.

Can you briefly describe how the robotic singulation and induction system retries in the case of unsuccessful picks and handles exceptions?

Georgiev: If we fail, we reattempt up to three times. It depends on if the system cannot establish contact with the package, or if we were able to grasp it but it's too heavy.

We have a patented reject mechanism of a paddle on the belt. It handles the majority of exceptions, such as if an item is too big or too high, or it's too porous for suction cups. If all of these fail, we call the local operator to resolve the issue.

Does MHS offer its systems for sale or through a robotics-as-a-service (RaaS) model?

Georgiev: While RaaS is popular, we sell systems as capex [capital expenditures]. We're in traditional automation and sell machines directly. It's better for ROI [return on investment] because the device monitors itself.

Activated Roller Belt (ARB) Singulator for large parcels. Source: MHS

What are some examples of applications or types of orders that are best addressed with dual-robot each picking from totes?

Georgiev: We've only scratched the surface for applications. For the past four years, MHS has focused on parcels for express couriers. With dynamic neural networks, it's now more possible to pick from random totes for fulfillment.

How much of the training on parcels or SKUs is done by MHS, an integrator, or the end user?

Georgiev: We work with outside contractors to supplement any limitations on resources. For this project, we've done it 100% internally, with millions of images collected from actual sites.

They're annotated and used to train the networks. We continually collect and annotate data to train and reduce errors.

The types of images we're looking at are both 2D and 3D. We developed our own industrial-grade camera five years ago.

How much do MHS's sortation systems communicate with inventory or packaging software?

Georgiev: Our robot singulation system communicates with only the sorter in the facility. The singulator inducts each package.

If we take it out from the express courier where the robots are and apply to the DNF [software package manager], then there's a need for integration with inventory software.

Currently, we're only building for the reservation of certain cells on the sorter. Beyond that, what happens to a package is beyond our control. We do keep stats on package dimensions for QA.

What are some things that you're working on for this year?

Georgiev: Most of the efforts we're doing right now is in decreasing the amount of human intervention. We're looking at possible causes of corner cases—packages getting stuck or being too large for the machine to handle and needing to get off the belt.

Sometimes, the robot may collide with package. If that happens, it stops and asks for an operator to inspect it.

As companies focus on singulation, if they add robots to replace labor, but then add labor to attend to robots, the ROI calculation is imprecise.

What are your goals for interventions and throughput?

Georgiev: Since robotics is a relatively new technology, there is not really an industry-accepted metric for human interventions, but we try to look through eyes of customers. For a facility with a single robot, if someone has to tend to it every 30 minutes, that's 50%, so it should definitely be less than an hour. We're actually aiming for one intervention a day.

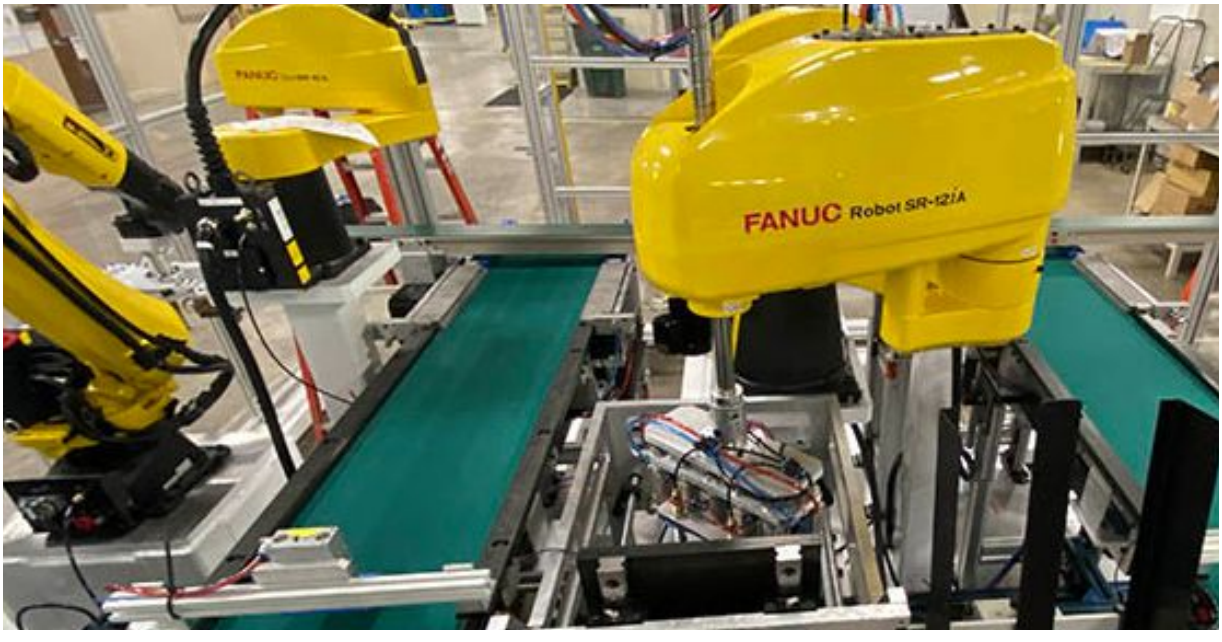
The industry takes widely different approaches. Some companies are doing remote interventions, but sometimes you can't fix a problem remotely. The high-level goal for our systems is to increase the throughput our system could handle. This involves not just improvements in the layout—for which MHS has plenty of experience as an integrator—but it also includes improvements in picking strategies. Sometimes robots are "starved," and there are not enough packages in lane delivery. Or there are bottlenecks, which we can also solve.

We've solved about 95% of picking problems, and it will take quite a bit of effort to move from 95% to 96%. We've already addressed the "low-hanging fruit" of integration. •

Eugene Demaitre *is editorial director of* Robotics 24/7.

North American Robot Sales Reach New Records for Third Quarter in a Row, Says A3

The Association for Advancing Automation reported that the industry has returned to historic norms, with automotive manufacturing leading and e-commerce interest growing.



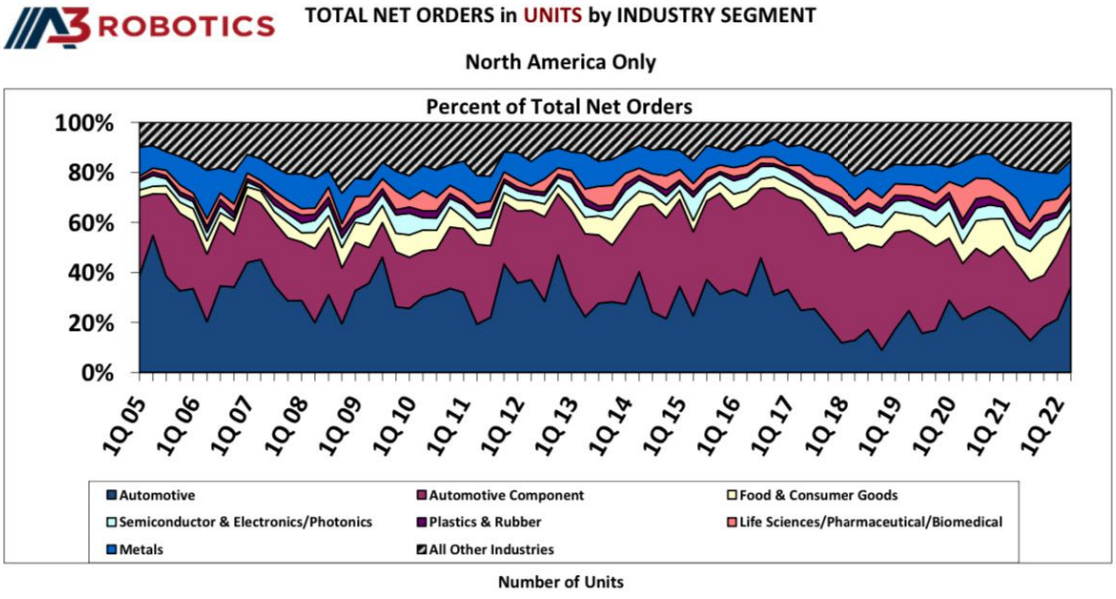
FANUC has observed strong orders for industrial automation in North America. Source: FANUC America

BY EUGENE DEMAITRE

Robot sales in North America hit a record high for the third quarter in a row, according to the Association for Advancing Automation. The growth was driven by a resurgence in sales to automotive companies and increasing demand for logistics automation in e-commerce, said the association.

Of the 12,305 robots sold in the second quarter of 2022, 59% of the orders came from the automotive industry, said the Association for Advancing Automation (A3). The remaining orders largely came from the food and consumer goods industry, which saw a 13% increase in unit orders over the same period of April through June in 2021.

"While this quarter shows a marked shift back to historic norms, with more robots going to automotive than to any other industry, the continued growth of robotics in food and consumer goods companies especially demonstrates the ongoing need to automate warehouse logistics for handling the exploding growth of e-commerce," stated Jeff Burnstein, president of A3.



The automotive industry again took top spot in North American robot sales in Q2 2022. Source: Association for Advancing Automation

North American robot revenues keep climbing

The 12,305 units sold in Q2 2022 is 25% more than the amount sold in the same period in 2021 and 6% more than the 11,595 sold in the first quarter of 2022, said A3. The Q2 2022 value of $585 million is the second-best quarter ever for revenue, according to the organization. That was down 9% from the $646 million in revenue of Q1 2022, the previous record quarter.

When combined with 2022's first-quarter results, the North American robotics market had its best start ever, with 23,903 robots ordered at a value of $1.249 billion, A3 said. The market grew 26% and 29% for units ordered and revenue, respectively, over 2021.

A record fourth quarter in 2021 resulted in the strongest year ever for North American robot sales, with 39,708 units sold at a value of $2 billion. A3 noted that 2022 is on pace for another record year.

"The larger trend towards robots being used to benefit more companies in North America continues," Burnstein added. "This makes it critical to educate system integrators and users now about how to deploy robots while keeping workers safe."

A3 observes demand across industries

While the automotive industry was again the biggest buyer of robotics in North America, adoption is growing across industries, said Alex Shikany, vice president of membership and business intelligence at A3.

"We're now on the path to realizing what we've been saying for a long time – a record number of companies of all sizes in all industries are looking at an ever-expanding set of applications," he told *Robotics 24/7*. "We're starting to see issues facing manufacturers – labor, inflation, productivity – come through in the data we collect."

"In Q2 in particular, we saw a resurgence in automotive OEMs and components," noted Shikany. "The cyclical industry is coming back in a big way, with electric vehicles driving retooling of existing facilities and construction of new ones, which will use a lot of automation."

"E-commerce, electronics and semiconductors, and life sciences were hit hard by labor shortages and are still on trajectory," he said. "Some manufacturers have told us that they're slowing down on purchasing to focus on implementation."

FANUC sees an 'inflection point'

"This is a true inflection point for our industry," said Louis Finazzo, vice president of sales at FANUC America. "Everybody is familiar with using robots for the 'Three Ds'—dull, dirty, or dangerous tasks. Now I'm adding a fourth, 'desire,' because of the skills gap, onshoring, and lost opportunity costs. Companies are saying, 'We can't wait anymore; we have to move now,' because of robots' ability to be redeployed, flexible, and maximize returns for customers."

"For example, electric vehicles [EVs] have justified increased automotive spending," he told Robotics 24/7. "In what I would call 'mid-volume, mid-mix, and rapid change requirements,' the industry is buying automation at a record pace to keep up with launch curves that used to be 55 to 60 weeks and are now 24 weeks. They want to be prepared for EVs and not lose market share."

"I've never seen this in 30-plus years in the automotive industry—spending driven by changing architectures," Finazzo noted. "So many things are being developed there that will apply to other industries."

Other industries to benefit from cobots, reshoring

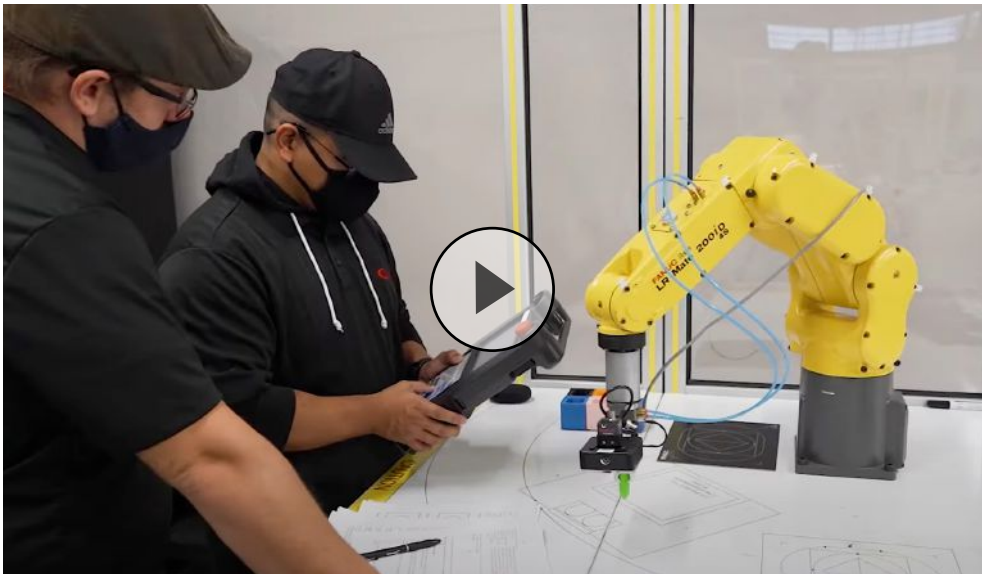
"Healthcare, pharmaceuticals, and e-commerce demand went up because consumers couldn't go out like normal [during the COVID-19 pandemic], said Finazzo. "We're seeing new customer activity at record highs."

"In addition, collaborative robots subsidize labor rather than replace it," he said. "You can take one skilled person, add three robots, and still come out ahead. When cobots came out, there were a lot of false starts around safety, which depends on the end-of-arm [tooling and payloads]. But their ease of programming has been tremendous for processes like welding and assembly, where that skill set doesn't exist anymore."

"We're also seeing people designing for cobots and new tasks, such as quality inspection," Finazzo said. "It's also important to educate the next workforce to fully utilize this equipment. FANUC has a lot of training and has implemented apprenticeships."

Reshoring is another part of the equation. "Companies may look at smaller profit margins on things built here, but with smaller locations and more automation, it's not about labor first and location second," he observed. "In die casting, forge pressing, and general product assembly, companies are now investing in North American facilities built around automation."

Robotics vendors have their



A3 offers multiple events

A3 said it will discuss the North American robotics market at several upcoming events.

- **The International Safety Robotics Conference** (ISRC) on Sept. 27 to 29 in Columbus, Ohio, will address the latest safety standards and share best practices and use cases to help companies safely succeed with automation.
- **The Artificial Intelligence & Smart Automation Conference** on Sept. 29 in Columbus is intended to help attendees "start their journey to unlock the power of AI," said A3. It will feature discussions on data strategy; advances in AI, robotics, and machine vision; and AI-powered optimization and prediction.
- **Autonomous Mobile Robot (AMR) & Logistics Week**, scheduled for Oct. 10 to 13 in Boston, will be co-located with The Vision Show. It is designed to provide the right solution providers, technology, and expertise to implement vision and imaging systems.
- **A3's Business Forum**, from Jan. 16 to 18, 2023, in Orlando, Fla., is an annual networking event for robotics, vision and imaging, motion control and motors, and AI industry professionals.
- **The Automate Show,** planned for May 22 to 25, 2023, in Detroit, is "the largest showcase of automation in North America," claimed A3.

own supply chain challenges.

"I describe robotics as an accelerant or a catalyst," Finazzo added. "Everyone is selling to capacity, as demand outpaces supply. There's so much pent-up demand, that it will take a while to catch up from shortages in chips. I'm very bullish."

"There's an industry-wide focus on customer communications and being upfront about shipping and availability of components," Shikany said.

"We're excited to share the latest on robots in the logistics space at our upcoming AMR & Logistics Week," said Burnstein.

"There was a day when people went to the Vision Show just looking for components," said Shikany. "Now, it's robots, AMRs, AI, and software. Attendees can see more and meet everybody in one place rather than find siloed technologies. Automate also saw a record number of companies excited to come back."

In addition, Shikany will discuss the end-of-year numbers in detail at the next A3 Business Forum.

A3 said its members includes nearly 1,100 automation manufacturers, component suppliers, systems integrators, end users, academic institutions, research groups, and consulting firms. •

Eugene Demaitre *is editorial director of* Robotics 24/7.

SICK and Aeva Partner to Bring 4D Lidar to Industrial Sensing Applications

The Aeries II is equipped with more precise sensor data that provides autonomous systems with better navigation information.

BY ROBOTICS 24/7 STAFF

The Aevia Aeries II. Source: Aeva

Aeva Technologies Inc. and SICK Sensor Intelligence announced a strategic multi-year collaboration to use Aeva's 4D lidar technology on a variety of systems used for industrial applications. The partnership starts with the Aeries II, Aeva's 4D lidar system that has camera-level resolution and uses the company's Frequency Modulated Continuous Wave, or FMCW.

The Mountain View, Calif.-based company introduced the Aeries II in February. Aeva said its proprietary 4D perception technology provides up to 20 times the resolution of legacy sensors. That enables autonomous vehicles to see up to twice the distance, the company claimed. It also said its lidar technology has better dynamic range performance to perceive low and highly reflectivity targets within the same measurement without edge effects. That allows automated machinery to transition easily from indoor to outdoor operations.

The company said its mission is to bring the next wave of perception to a range of devices including automated driving systems, industrial robots, consumer electronics, health care devices, and security devices.

A strong partner on its side

With more than 50 subsidiaries, SICK is also a technology company. It is based out of Waldkrich, Germany and makes a range of sensors and accessories. With more than 50 subsidiaries and equity investments as well as numerous agencies, SICK maintains a presence around the globe. In the 2021 fiscal year, SICK had more than 11,000 employees worldwide and a group revenue of around EUR €2 billion (U.S. $2 billion).

"We are pleased to partner with Aeva and work closely together to bring its FMCW technology to high performance industrial sensing applications," said Dr. Niels Syassen, member of the executive board responsible for technology and digitization at SICK. "We are convinced that their unique approach to FMCW technology, which includes instant velocity detection and long-range performance, will provide new opportunities for us and our customers in a variety of industrial sensing applications where traditional time of flight lidar technologies are challenged."

Because Aeva's technology is immune to blooming and ghosting from retroreflectors, automated machines using Aeva's 4D lidar will have clear perception when highly reflective objects such as safety vests, cones and tape are in the field of view of the sensor, Aeva said.

The technology detects low and highly reflective objects such as safety vests, pylons and adhesive tapes in the sensor's field of view. FMCW helps increase reliability and efficiency in demanding 3D applications.

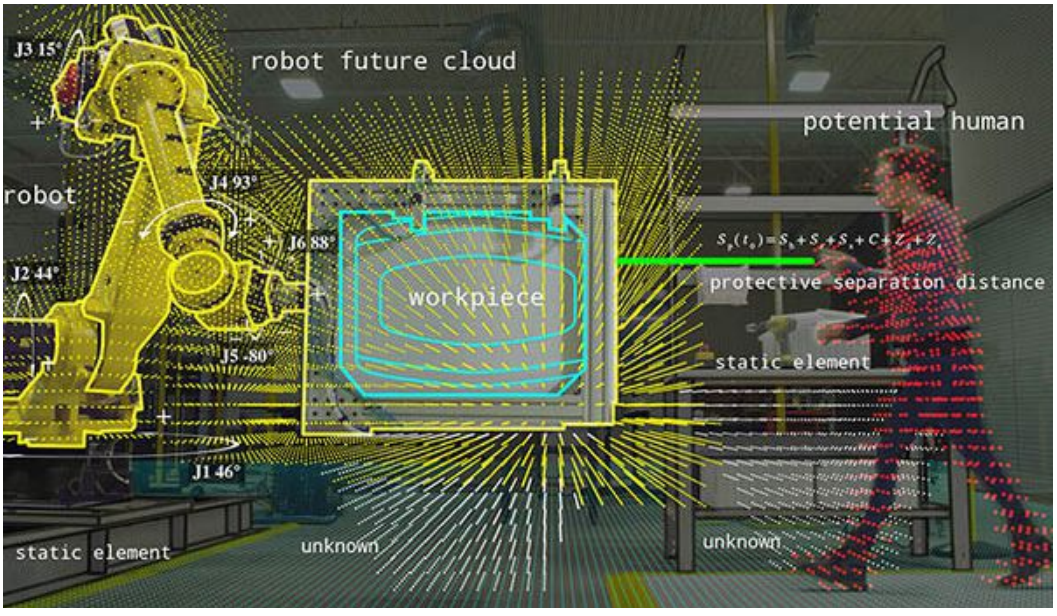
"SICK is one of the foremost leaders in industrial sensing solutions and today's partnership is a major step forward for the advancement of high performance and reliable FMCW-based sensing across a broad set of industrial applications," said Soroush Salehian, co-founder and CEO at Aeva. "This strategic collaboration is a testament to the industry-leading performance and versatility of our unique 4D lidar technology for scaled deployment in industrial applications." •

6 ROBOTICS FIRMS MAKE LIST:

Top 50 Most Promising Private Advanced Manufacturing Companies

Veo Robotics was among the robotics companies in CB Insights' "Advanced Manufacturing 50 List" for this year

BY ROBOTICS 24/7 STAFF



Veo Robotics' FreeMove is intended to make industrial robots safer around human workers. Source: Veo Robotics

Robots are becoming a significant part of leading production operations, according to a new report. The "Advanced Manufacturing 50" is CB Insights' annual list of promising private, advanced manufacturing companies in the world.

"Some of this year's winners aim to provide robotic systems to help manufacturers increase productivity and reduce labor costs," said CB Insights. "Others are developing advanced analytics that will allow manufacturers to maximize the efficiency and quality of their processes, systems, equipment, and more.

The New York-based software vendor's research team used the CB Insights platform and evaluated more than 6,000 applicants and nominees based on their research and development activity, proprietary Mosaic scores, investor profiles,

competitive landscape, and technology novelty, as well as its analyst briefings.

Honorees raise billions toward robots, AI, analytics

This year's honorees have raised more than $3.75 billion in 46 deals last year alone, with 12 "unicorns" or valuations above $1 billion, said CB Insights. It noted that industrial automation and collaborative robots were the second largest part of the cohort at 12%, behind factory analytics and artificial intelligence at 16%.

"This initial cohort of the AM 50 includes a wide range of companies at different stages of maturity, product development, and funding," stated Brian Lee, senior vice president at CB Insights' Intelligence Unit. "Collectively, they are working on everything from factory analytics and artificial intelligence to the industrial Internet of Things [IIoT] and cybersecurity."

"We're excited to watch the companies on this year's list continue to grow and further create operational efficiencies that will have a meaningful impact across industries," he said.

This year's robotics and cobot winners included the following:

1 Exotec SAS makes the Skypod scalable storage system and the Skypicker robot arm for retail order fulfillment. The company, which recently moved to Wasquehal, France, near Lille, recently announced its 3,000th robot and has raised about $447 million to date.

2 LINKWIZ Inc. said its L-Robot software enables robots to automatically correct their own movement in manufacturing environments. The Hamamatsu, Japan-based business has raised $17 million and also makes the L-Qualify 3D robotic inspection system.

3 Locus Robotics Inc. provides autonomous mobile robots (AMRs) to improve piece-handling productivity. The Wilmington, Mass.-based company, which has obtained a total of $316 million, said its technology can be integrated into existing warehouse operations without disrupting workflows.

4 Novarc Technologies Inc. has commercialized collaborative robots and AI for automated welding in pipe-fabrication shops. The startup has raised $3 million and is based in North Vancouver, British Columbia. It offers the Spool Welding Robot (SWR), the SWR+HyperFill integrated dual-torch system, the NovEye vision and image-processing system for fully automated welding, and NovSync for data analytics.

5 Rokae Technology Co. in Beijing provides a cobot, a six-axis robot, and the Titanite control system, as well as custom support. Founded in 2015, the company has received $138 million and partnered with German firm Jaeger Engineering to expand in the growing European market.

6 Veo Robotics Inc. has developed sensors and software for FreeMove 3D, which provides dynamic speed and separation monitoring so that industrial robots can safely collaborate with humans. Human-robot collaboration is a priority for six out of 10 manufacturers, according to Veo. The Waltham, Mass.-based company's technology detects if a human enters a workspace and automatically slows or stops the robot. When the person leaves, the robot can resume operations at speed.

Veo Robotics reacts to recognition

"We're proud to be recognized by CB Insights for our technology's ability to improve safety, productivity, and working conditions for manufacturers," said Patrick Sobalvarro, co-founder and CEO of Veo Robotics.

"As manufacturers have been challenged by the pandemic, supply chain constraints, and labor shortages over the last few years, they've only increased the number and use of industrial robots within their facilities," he added.

Veo claimed that FreeMove is "the only product currently available with the safety design needed to now unlock the true power of human-robot collaboration on their facility floors."

The company has raised $28 million to date, from investors including GV (formerly Google Ventures), according to CB Insights. Veo provides computer vision to the world's top robotics vendors: ABB, FANUC, KUKA, and Yaskawa. •

Advantech and Overview Combine Tech for Real Time AI Inspection System

Partners say Advantech's edge AI camera and Overview's deep learning systems can help manufacturers detect and identify defective products early.

BY ROBOTICS 24/7 STAFF

Advantech ICAM-500 series is a highly integrated industrial AI camera equipped with NVIDIA Jetson AI system on module. Source: Advantech

Manufacturers must contend with high turnover, as well as yield, traceability, manual inspection costs, and shrinking margin concerns. Conventional visual inspection is not only time-consuming and costly, but also prone to human error. Advantech Co. and Overview last month joined forces to offer an "end-to-end" artificial intelligence system for vision inspection.

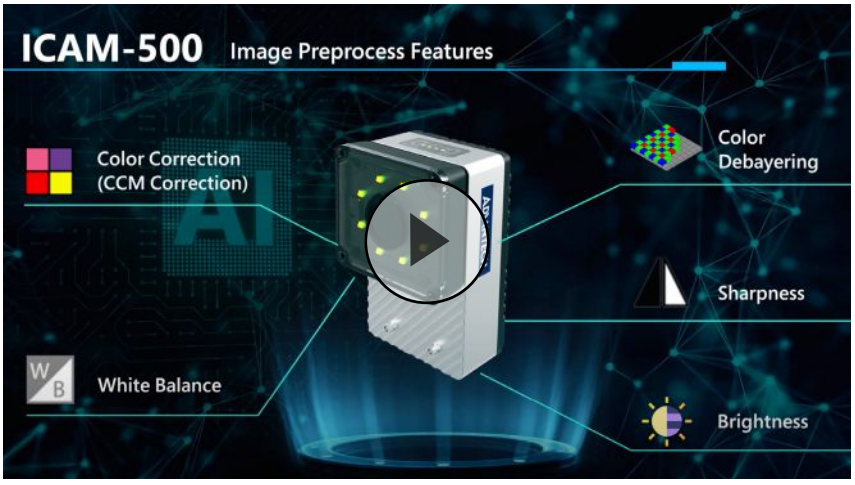
Founded by Tesla automation engineers, Overview develops platforms using deep learning to automate and improve inspection processes. The San Francisco-based company said its cameras and next-generation AI can improve the speed and reliability of inspections while saving companies significant costs. Overview said it has designed its product specifically for flexibility and ease of use, allowing accessibility to all manufacturers, regardless of size or specific use cases.

"We started Overview in 2018 because after years of building automation equipment for Tesla, we became frustrated with the experience of trying to implement vision systems for quality checks," wrote the company in a blog post. "Vision to us meant $30,000 in hardware, no connectivity, an ancient user interface, and a requirement of steep technical knowledge and training."

"It also meant that you could write a 200-line algorithm to handle the variance in your process, only to have it totally break under the slightest

change in the product or environment," said Overview. "It also meant being capped at mediocre accuracies with no obvious path forward—other than a complete hardware redesign or fixing a spiderweb of algorithm code."

"We believed that a combination of deep learning—which is superior at handling variance and achieving high accuracies—with the ability to access a vision expert with a single mouse click would fix this," the company added. "We knew, however, that software alone cannot solve difficult problems in manufacturing."



Edge camera plus deep learning equals quality

Founded in 1983, Advantech is a leading provider of industrial Internet of Things (IIoT) and edge hardware technology. The Taipei, Taiwan-based company said its IIoT hardware and software can assist business partners and clients in connecting industrial chains. Advantech, which has U.S. offices in Irvine, Calif., also works with domain-focused partners to co-create IIoT systems.

The combination of Advantech's new ICAM-500 edge AI camera and Overview's deep learning technologies will help manufacturers improve quality control, traceability, and speed for production-line operations, said the companies.

A reliable, automated visual system can review product assembly at each stage of the manufacturing process, which simplifies and improves product inspection, the partners said. AI and automation can eliminate the complexity of finding good and bad products, leading to zero defects in the manufacturing process, claimed Advantech and Overview.

"Together, we deliver more imaging and AI horsepower than existing vision systems with a far better user experience, and for a fraction of the price," said Overview.

Overview Snap Platform handles multiple tasks

Overview said its Snap Platform from Overview is an adaptable machine vision system that handles everything from device management and algorithm development to product quality support and traceability. When integrated with smart cameras such as the Advantech ICAM-500, the Snap Platform can automatically inspect from a programmable logic controller (PLC) trigger, interval, or—in the case of video events—continuous capture.

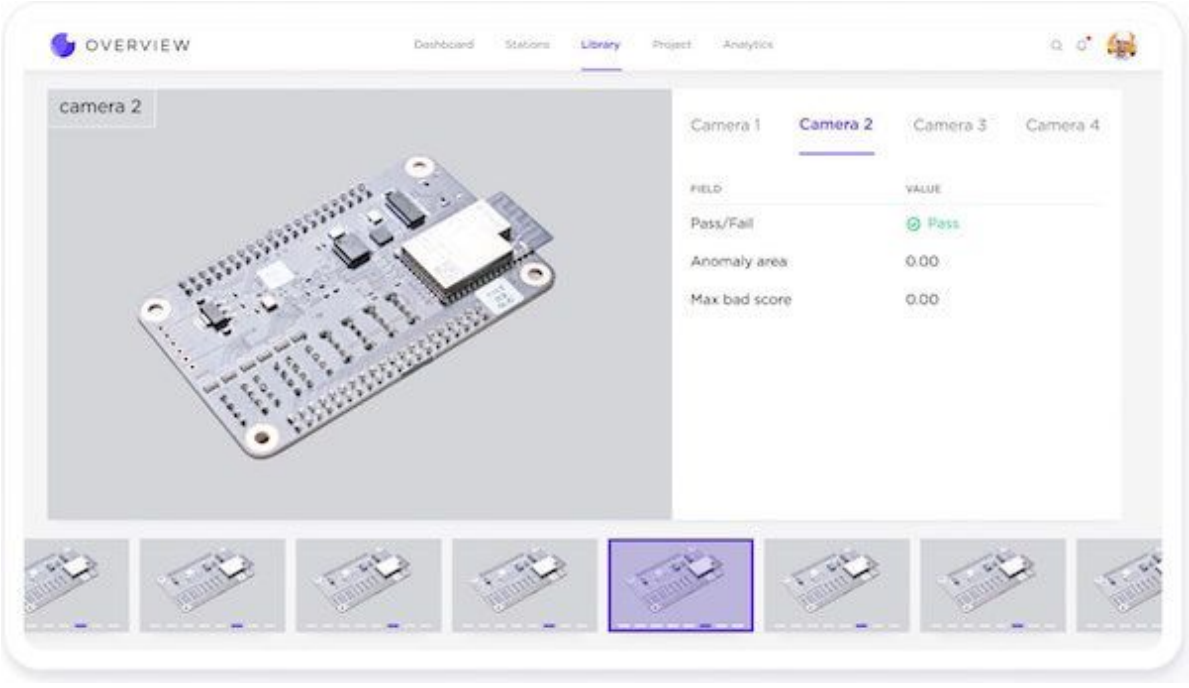
"We are continually evolving our Snap Platform to provide new and existing customers with easy-to-use, powerful inspection systems that also grow and scale with changing business and quality needs," said Chris Van Dyke, CEO of Overview. "By partnering with best-in-class hardware providers for a reliable, end-to-end solution, we make device setup easier and faster. We are excited to bring Advantech into the fold and integrate our Snap platform with its high-quality, industrial edge AI devices."

Unlike a typical vision system, the Snap Platform saves all relevant process data and creates a traceable visual record of every unit, said Overview. It catalogs data for easy search and analysis.

This helps with traceability, as well as the discovery of yield loss sources, the company said. Users can determine the root cause of losses with data post-processing.

Advantech uses NVIDIA modules in camera

Embedded with NVIDIA Jetson Nano modules, Advantech's new ICAM-500 AI camera combines an industrial-grade image sensor, advanced LED lighting, and a variable focus



Overview said its Snap platform offers enhanced traceability with remote access and support. Source: Overview.ai

lens with acquisition and AI computing capabilities.

The company said these features enable systems integrators and software vendors to integrate AI and machine vision into applications. They can also efficiently perform AI automated optical inspection (AOI), AI optical character recognition (OCR), and object recognition at the edge.

"The ICAM-500 is a unique device, as the combination of NVIDIA computing modules and camera system offers image acquisition and AI inference functionality all within the same system," said Carolyn Swan, director of IoT partnerships in the Advantech IIoT Group. "Integrating the ICAM-500 with the Overview Snap platform creates a state-of-the-art solution for the manufacturing industry."

"Our built-in camera helps reduce latency challenges that usually occur due to the distance between IP cameras, the cloud, and AI inference systems," she said. "That low latency improves efficiency of on-site AI inference, creating an ideal solution for edge AI applications on the production line."

Advantech and Overview said customers can deploy and manage their combined system without high-level technical expertise. Overview experts support the Snap Platform remotely, so customers do not need on-site machine learning experience.

It also integrates with existing factory systems and communicates across networks to accomplish more efficient, lean, and profitable operations, said the company. The Advantech ICAM-500 is available now. •

Kawasaki Robotics Chooses Realtime Robotics for Programming, Deployment, and Control of Robots

The companines presented an interactive demo cell of RapidPlan software and BX100N robots at Automate.

Realtime Robotics is demonstrating its software at Kawasaki's Automate booth this week. Source: Realtime Robotics

BY ROBOTICS 24/7 STAFF

DETROIT—Realtime Robotics recently announced that it has teamed up with Kawasaki Robotics Inc. to automate the programming, deployment, and control of industrial automation.

Wixom, Mich.-based Kawasaki and Boston-based Realtime Robotics have collaborated to build a demonstration cell. It was at Kawasaki's Booth 232 at Automate 2022, which took place at the Huntington Place Convention Center this summer.

The spot-welding cell displayed the combined power of Kawasaki Robotics' KRNX open programming platform and Realtime Robotics' motion-planning and collision-avoidance software, integrated with two Kawasaki BX100N robots.

KRNX is an application programming interface (API) plugin that enables real-time control (RTC) by advanced users to execute complex and irregular applications. Realtime said KRNX allows Kawasaki robots to use unlimited external computing power, enabling anything from AI and machine learning applications to advanced safety.

A deeper look at Kawasaki's demo

Two Kawasaki BX100N robots simulated the welding of a car door using ARO 3G modular spot-welding guns. Realtime Robotics said its RapidPlan software enables show attendees to see firsthand how quickly and efficiently robot motions can be modified—all without any reprogramming or manual verification of motion planning.

Users can start, stop, or reset all or any individual robots; modify target allocation; change target order; and add or remove existing targets to the robot sequence, said the company.

Realtime Robotics and Kawasaki have partnered on several projects, including helping a major automotive manufacturer improve the speed of programming by 70%. This manufacturer reduced the pre-production engineering commissioning process through the use of automatic,

Kawasaki will demonstrate a BX100N robot welding a car door using the RapidPlan software. Source: Realtime Robotics

collision-free motion-planning technology. In the future, it could eliminate the time-consuming physical validation of robot paths altogether, claimed the duo.

"The combination of Kawasaki's quality robots [and] advanced programming platform and Realtime Robotics' software is an industry game changer, providing manufacturers from all industries with unprecedented flexibility, from automating programming of robotic motion and collision avoidance to the very design of the manufacturing floor," stated Kazuhiro Saito, president of Kawasaki Robotics. "This is the future of automation, and the very best is yet to come."

Depending on the complexity of the project, the number of robots the customer programs, and whether they are starting from scratch or simply making modifications, programming requirements can be shortened by weeks with Realtime Robotics RapidPlan software, the company said.

Realtime's RapidPlan helps prevent collisions

During the on-site physical validation stage, a user typically needs to have a highly skilled team working after hours to manually run through every move combination, ensuring seamless operations on the live factory floor. Because RapidPlan produces collision-free paths, it automatically removes the need to verify against potential collisions, resulting in significant time savings, the company claimed.

"Today's automotive manufacturers don't have time or staff to waste," said Peter Howard, CEO of Realtime Robotics. "Factory floors and all related actions must be constantly optimized in order to maintain a competitive advantage and continue delivering excellent product to customers."

"Kawasaki Robotics is a terrific partner to work with, as they understand how speeding or eliminating time-consuming and manual processes can directly improve a manufacturer's production time—and its profits," he noted.

Expanding on an established partnership

It is easy to make a mistake, such as grabbing the wrong teach pendant and jogging the robot in the wrong direction, causing a collision. RapidPlan will alert the user of a collision about to happen, in order to prevent it.

"Kawasaki was one of the first robot companies to see the potential of combining an advanced Real Time Control API like KRNX with our RapidPlan real-time autonomous motion planner to enable a whole new way of designing and deploying robotic systems," Howard said.

"We feel privileged to have had continuous support from their quality robot family, interface, and people in realizing our joint vision for what the future of robotics should look like," added Howard. •

Motor Technology Improvements Make Robots More Capable

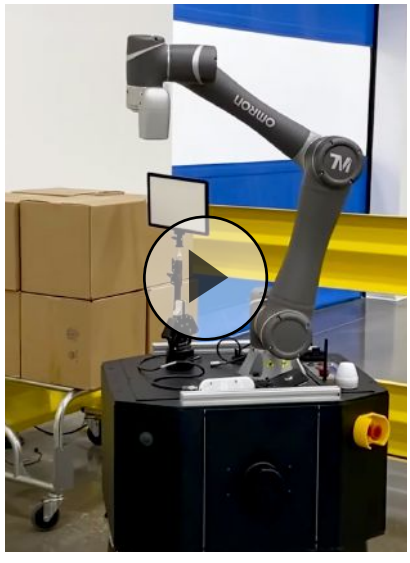
Engineering advances in motors and drives are making robots more efficient for a variety of applications.

BY TOM KEVAN

New motor and drive technologies are enabling safer and more precise robots. Source: Omron

Advanced motor technologies are helping improve tasks robots can perform, helping to make them stronger, nimbler, and more sustainable. Empowered with these enhancements, a new class of robots has begun to take on tasks in industries that haven't typically taken advantage of automation.

Market demand for compact and energy-efficient mobile robots continues to grow. At the same time, advances in automation manufacturing have helped improve today's motors in multiple ways.



Motor advancements bring more accuracy

Greg Diek, product manager for motion at Omron Adept Technologies, said a critical area of improvement "is better accuracy while winding the coils for motors. This allows for smaller windings that still create the same amount of power for the motor," he added.

"Another is the newer permanent magnets that allow more power and smaller motors. Then, with more accurate machining, manufac-

turers can reduce the air gap between the coils and magnets, which makes the motors not only smaller but more efficient as well," he said. "Making components smaller and more efficient allows increasing the torque-to-weight ratio, and this allows developers to increase robot payload and/or make them smaller."

Feedback devices have also improved in size, precision, and quality. "With higher-resolution encoders, we not only see better accuracies, but tuning can also be improved to help with accuracy and cycle time when applied to the applications," said Dieck. "This opens the door for higher-precision robotics applications, and it improves repeatability and the throughput of the robot and automation."

Furthermore, smaller motors with better torque-to-weight ratios allow motors to achieve high peak speeds for a short time, as well as faster acceleration and deceleration times. This allows robots to have a reduced mass, which in turn permits more rigidity and reduces vibration.

Upgrading robot arms

Motor advances have also enhanced the capabilities of robot arms, joints, and end effectors.

"Think about the present-day robot arm," said Paul Kling, motion division market segment manager for packaging and material handling at Yaskawa America. "In many cases, motors are buried inside the robot housing so the ability to use smaller motors has dramatic advantages. Smaller motors lead to smaller housings, which lead to less mass to move."

In the case of a six-axis articulated robot arm, the smaller the motors, the less mass, and the faster the speeds the robot arms can move, Kling said.

Cobots need small motors that pack a big punch

An example of how advanced motors can open the door to new, more sophisticated applications can be seen in the evolution of collaborative robots, or cobots. As developers and users continue to flesh out cobot functionality, demand for greater reaches, payloads, and speed has grown.

Paralleling this trend is a drive for higher power- and torque-density, with an eye on improving cobot performance while maintaining the machine's ability to work safely with human operators.

To meet these demands, some robot developers are turning to direct drive frameless torque motors. "High-performance torque in the shortest and lightest

electromagnetics package possible delivers lower joint weight, high load-carrying capacity, energy efficiency, lower thermal rise, and faster movements with greater smoothness of motion," said Yoshi Umeno, global market manager for robotics at Kollmorgen.

"The result is smaller, lighter, faster, and stronger robots. Small motors with a high output are essential if the arms and joints are to be made as compact as possible," Umeno added.

Armed with these capabilities, frameless motor-enabled cobots have begun to move beyond traditional industries like automotive into other sectors, such as retail, food preparation, and healthcare.

In the operating room

One of the more prominent new applications is robotic-assisted surgery. Here, robots allow surgeons to perform minimally invasive procedures that help patients recover more quickly and completely across an ever-increasing array of treatments, including orthopedic, laparoscopic, cardiac, and even optic procedures.

"Today's surgical robots must deliver precise, smooth, and quiet operations for acceptance by hospitals and surgeons," said Umeno. "Like a skilled surgeon, sometimes the robot's movements must be slow, yet deliberate, requiring critical haptic feedback and torque-dense motors for precise control.

"New torque-dense frameless motors enable smaller, lighter arms and the highest definition control, Umeno added. "These servo motors are ideal for the gantry and columns, which position robotic arms over the patient."

When robots go mobile

Autonomous mobile robots (AMRs) have also begun to take on more demanding tasks, ranging from warehousing to a growing number of hospital applications. These include infection control, biochemical specimen delivery, and general medical tasks. AMRs are also playing roles in the fight against the COVID-19 pandemic.

Part of the appeal of these robots lies in the fact that they are inexpensive and simple to implement. That said, AMR developers still have obstacles to overcome.

"Typical challenges include extending the run time of battery-powered devices, robust designs that can contend with harsh environments, and accurate movement control—start/stop—for safe operation around humans," said Julian DelCampo, business development manager at Portescap.

To meet the requirements, mobile robots require motors to have more streamlined form factors than their predecessors. This translates into compact and lightweight yet durable motors. AMRs also require higher levels of performance.

To meet these requirements, as well as boost the performance of AMR motion systems, some developers have turned to brushless DC (BLDC) motors, coupled with compact planetary gearboxes to achieve high torque and encoders for positional feedback.

"AMR mini motors are able to fulfil the requirements for high torque, low moment of inertia, and the ability to work under load," said DelCampo. "BLDC motors also achieve a long, trouble-free life because there is no mechanical commutation and therefore wear of brushes." •

Tom Kevan *is a freelance writer/editor specializing in engineering and communications technology.*

Automatica Offers Peek Into Future of Robotics, AI

Looking to the next five years and beyond, robotics expert predict an increase in flexible and more dynamic systems.

A crowd at the Automatica trade show last month. Source: Automatica

BY PHIL BRITT

The future of automation was very much in focus at the Automatica trade show this past summer. Over 570 exhibitors from 35 countries and more than 28,000 visitors from around 75 countries made their way to the robotics and automation trade show in Munich, Germany, according to trade show organizers.

In terms of keynotes, panel discussions, presentations and live demonstrations, there were more than 150 of them. Here are some insights from the show.

Industrial automation growing

By 2026, the industrial automation market in Europe, the Middle East, and South Africa and Africa will be worth $51.4 billion, Peng-San Cau, LV vice president of Emerging Markets & Symphoni at ATS Automation, said during a session looking at the future of automation. Much of that money will come from manufacturers who are looking to automation to build flexibility, increase resilience, and lower risk.

"Prior to COVID, automation met lower costs. After COVID, automation means flexibility and resiliency." Cau said. "Consumer demand for personalized unique products and services will not change due to COVID or any other short-term disruption. They are impatient for a business to design the latest products and build the machines and the process to bring those new products to market cheaply."

"And as these demands recur more and more frequently, you as manufacturers need the agility in your equipment to shorten time to market," she added. "In other words, in the modern world, agility is speed. Finally, agility wins today because of the reality of automation itself."

Automation is following an evolutionary path similar to that of computers

Cau compared automation's growth path to computers. "The first modern computers were built

to break communication codes in wartime. They were simple machines that allow humans to do a greater number of mathematical calculation quickly. And though they become smaller, faster, and more reliable, it took decades for us to understand the true promise of computers as they become more and more agile."

There are a few different ways that automation could evolve from its present state, Cau said. "Are machines going to become more specialized and product specific? Or is each one going to become capable of an ever-increasing number of tasks while going at a faster rate? Are we going to continue to build machine for single purposes are we going to incorporate Industry 4.0 where data drives design and information powers decision-making? Whatever comes next the future of automation is agility," Cau said.

"When I think about the successful factories of the future, I don't see a maze of custom machinery snaking around huge factories. I see standardized digital solutions," she added. "That take up less floor space, with less mechanical parts and is faster and more precise."

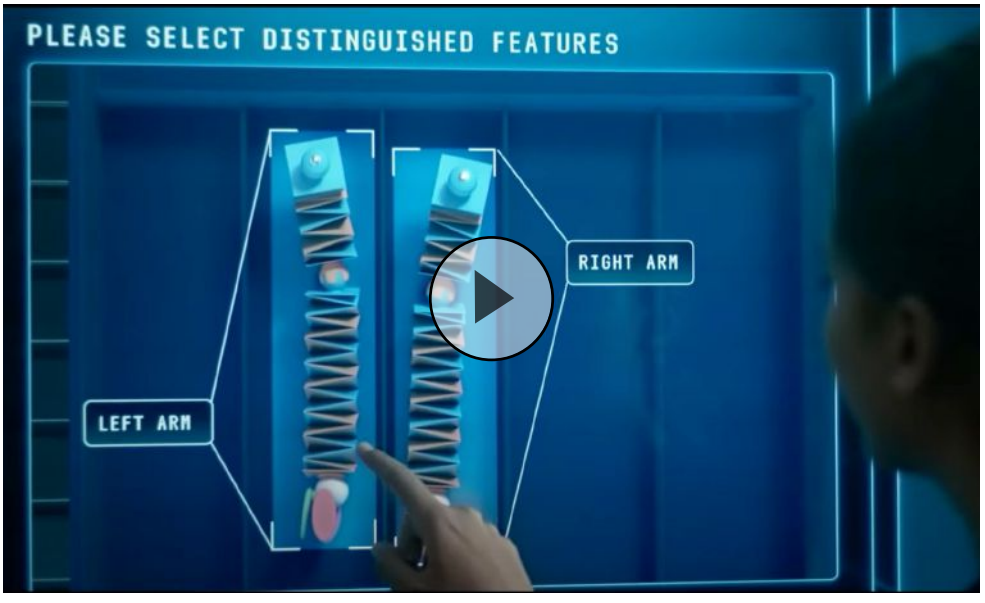
Automation systems that are modular and scalable reduce waste and are "good for the environment," Cau said.

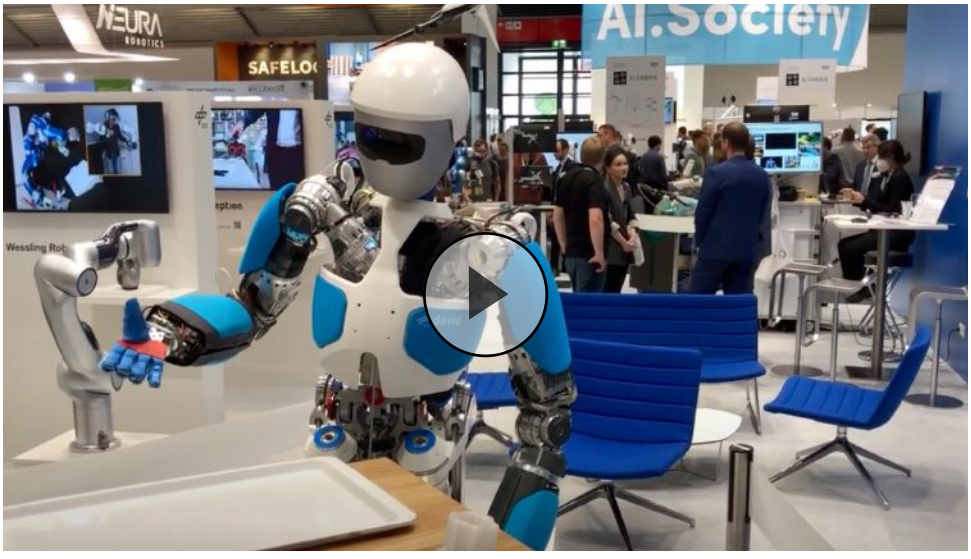
"I see a machine that can do one can do more than one thing and do it quickly," she said. "I see agile automation at the core of manufacturers sustainability strategy, modular and flexible solution means in more efficient intelligent and sustainable process for automated manufacturing."

"Usually, single-purpose machines take a factory space which eventually ends up in landfills," said Cau. "Agile automation is the very essence of sustainability."

Siemens explains 'autonomous factory of the future' concept

Matthias Loskyll, Siemens' director of autonomous factory and industrial AI, discussed in a session on the autonomous factory and AI that "the autonomous factory" will be designed by and for people





"The autonomous factory is our vision of the production of the future," Loskyll said. For such a factory to manufacture products on demand, there must me interaction with the supply chain, which delivers raw materials to the receiving area. Using AI technologies for object detection, automated transportation systems will load and unload materials.

Some more complex tasks will need to be handled by multiple machines, with "central intelligence" optimizing the overall production process together with interplant logistics processes, assigning machines with the adequate skills.

"But even the most intelligent systems using AI could reach certain limits," Loskyll cautioned. "For example, if they are not confident about a certain prediction, they will ask for help. This is a feedback loop between human and machine to give feedback to the system and let it learn continuously. So that's just a snippet of our vision of the autonomous factory of the future."

Intelligent systems will work closely with humans

Loskyll reminded the audience there will be an interaction between intelligent systems and human beings.

"There will be tasks that only can be taken over by humans because the human is in the end, unbeatable in terms of creativity in terms of problem-solving skills, in particular in situations that you haven't experienced before," Loskyll said. "It's all about the interplay between artificial intelligence and the right-hand side, where you have intelligent algorithmics, you have super-fast processing power [that] can process huge amounts of data."

"They are inside you a few minutes diligence, creativity and problem-solving skills, bringing these things together really getting the interplay done," he said. "This will be the next level of automation that we can achieve."

Robots will be critical in the autonomous factory, Loskyll added. An increasing number of intelligent robots are coming into various industry verticals.

Siemens uses robots for material handling. Other manufacturers, distribution centers and logistics centers are also increasing their use of robots, Loskyll said.

Yet there is room for growth for picking robots, which some in e-commerce don't trust for handling different objects. But with AI and computer vision, these robots – in use in many locations already – can calculate the optimal grasping point for every arbitrary object, even unseen objects at runtime, Loskyll said.

"This means you can throw any object that you want with a camera attached to the robot arm with the AI model, calculating behind the robot will be able to trust this object and to handle it and put it into the box," Loskyll added.

Siemens demonstrated such an operation at its booth at the trade show.

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