SMC
Automation • Controls • Process

Robots: the next generation

How more flexible robot designs are integral to the Industry 4.0 era

NC404A

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Robots: the next generation

If the pages of science fiction can claim credit for any real-life technology, then it's the industrial robot. Since the word famously first appeared in 1921, in writer Karel Capek's play R.U.R. (Rossum's Universal Robots), deriving from the Czech for "forced labor", robots have come a long way. They are today used in welding, painting, assembly and pick and place applications across a variety of industries.

Robots are not quite like "forced labor", of course, although robots and humans are forced to work hand in hand – in a good way. Each year, robots and collaborative robots are shown to enhance the work of humans. Industrial robots are running more production systems with their high endurance, speed and precision; while humans can devote more of their skills for strategic thinking, invention and detail.

Robots have evolved a great deal since the days of the large, cumbersome automatons seen on General Motors' production lines in the 1960s. But where do they fit into today's Industry 4.0 landscape, the era of automation and data exchange that continues to transform manufacturing technologies and processes?

This expert report explores the answer, looking at the evolution of robots and what we expect to see in their next generation. SMC is proud to say that our innovative, compact, lightweight and enduring robot components are crucial to this. Tomorrow's robots will offer flexibility and bespoke capabilities that the earliest models couldn't. They will be integral to realizing the industrial demands for smart factories, flexible and modular interconnectivity, and more powerful and reliable wireless connectivity on the factory floor.

“ SMC has always been an innovator in developing compact and lightweight products. Our components and standard, special or complete tailor-made solutions are used in all areas of industry - handling, pick and place, painting or welding applications. ”

Zdenek Velfl, Business Consultant CZ & SK, SMC Industrial Automation CZ s.r.o.

The first industrial robot

It was a love of Isaac Asimov's sci-fi writings, plus a fortuitous meeting with the American inventor George Devol at a cocktail party in 1956, that drove the engineer and entrepreneur, Joseph Engelberger, to form the world's first-ever robot company. Two years previously, Devol had invented the Unimate, the first-ever digitally operated and programmable robot.

In 1961, the Unimate #001 prototype was sold to General Motors and put to work in its New Jersey automobile factory. Later, in 1969, GM's recently rebuilt plant in Lordstown, Ohio, reported that its army of Unimate 1900 spot welding robots were building 110 cars per hour. These speeds, never achieved before, were double the rate of any other automotive plant at that time.

With these origins, it is clear that robots have always been desired for their speed, efficiency and controllability – and, of course, their benefits to the bottom line. With the Unimate 1900 series, GM jumped ahead of its competition while becoming the world's most automated car manufacturer. Yet, while the Unimate is undoubtedly one of civilization's most significant technological feats, its legacy also includes some of the largest challenges faced when applying robots to industrial settings.

Robots of previous years have been large, cumbersome – the Unimate #001 prototype weighed 2,700 pounds – and limited, in terms of both their design and the limited protocols used to control them. Industrial businesses often required specialized programmers and staff to control and program these robots, which made them inflexible for different working environments as well as expensive.

Today's engineers and designers are still striving to create more innovative, compact, lightweight and enduring robots – none of which are limited to the pages of science fiction, any longer!

Gradually, we are seeing the rise of the machines. According to the 2019 New Robotics report by the International Federation of Robotics (IFR), 2018 saw an annual record of $16.5 billion in sales of industrial robots. This was a six percent increase over the previous year and, going forward, the IFR forecasts an average growth of 12 percent, per year, up to the year 2022.

We expect that this growth will be driven by the automotive segment, yet it's clear that robots will be increasingly demanded in other segments, too, like food and beverage. Whatever the industry, there are certain common industry challenges.

Firstly, robot designs must fit into smaller spaces to suit manufacturers' growing concerns over "machine real estate", which means that every square meter of production space is used for production. There is also the ongoing question of how robots can fit in with Industry 4.0 technologies such as virtual and augmented reality and artificial intelligence (AI). This requires a level of connectivity and controllability that integrates, quickly and seamlessly, into the smaller spaces of any production line.

It is not simply a question of deploying more robots. There are also crucial questions of how best to implement these robotic systems, given the above challenges. That's why SMC maintains close working relationships with our customers like original equipment manufacturers (OEM), machine builders and end users. This is reinforced by SMC's 8,400 sales engineers across 83 countries, 36 production centers and five technical centers, worldwide.

Working closely with our customers inspires SMC to find new ways to help evolve their robots for new applications. Some of these innovations are described over the following pages.

> *"SMC has implemented its own Voice of the Customer (VoC) program, which are increasingly popular within industry as a way to capture customers' preferences and opinions. SMC will produce 3D-printed prototypes and take these to the customer, to inspire them and present them with something tangible.*
>
> *This process is especially beneficial in robotics where, what initially seems like a small gain can have a significant knock-on effect."*
>
> Peter Humphreys, Product Manager, SMC UK

Lightweight, more efficient

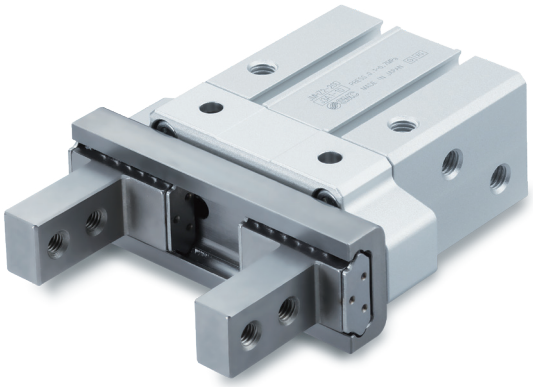
SMC has always been an innovator in developing compact and lightweight robotic products. Not only must these systems be lighter, but they should also have reduced inertia movements for increased speed and efficiency.

A couple of years ago, SMC set out to decrease the weight on robotic arms and has been developing its J-Series, which offers more types of products that can be used in robot arms. The series includes the JCQ double acting, single rod, compact cylinder that weighs only 25 g, and the compact and lightweight JMGP dual rod cylinders with side bearing. Also, the JSY five-port solenoid valve with the thinnest valve width in the world for greater space efficiency, and the JMHZ air gripper (pictured below) that is designed for use in compressed air systems.

These components were designed for use in special robot arms. Importantly, smaller and precise engineered components such as these are crucial to ensuring robots are lighter and smaller overall, with more precise movements. This, in turn, leads to increased speed and efficiency.

Meanwhile, end-of-arm tooling is another key innovation in robotics that will push the limits of human innovation. Grippers for robots, or clamping systems for machining centers, are getting more precise; so sophisticated that they can handle the fragile silicon wafer computer processors that are so vital in electronics. Non-contact grippers can also be suitable for the semi-conductor industry; like vacuum grippers that have the potential to provide energy efficiency in any application.

Sensors can be used in any kind of industry; to derive data from, and improve control of, robotic workers for higher-quality results. Among SMC's main objectives is to make sensors and actuators more intelligent to provide more big data for upper-level management. Innovations like force/torque sensors can help locate and detect an object's presence for greater accuracy. Sensors can also be better connected by less-expensive protocols, like IO-Link, which is very easy to use and can join both old and new technologies.

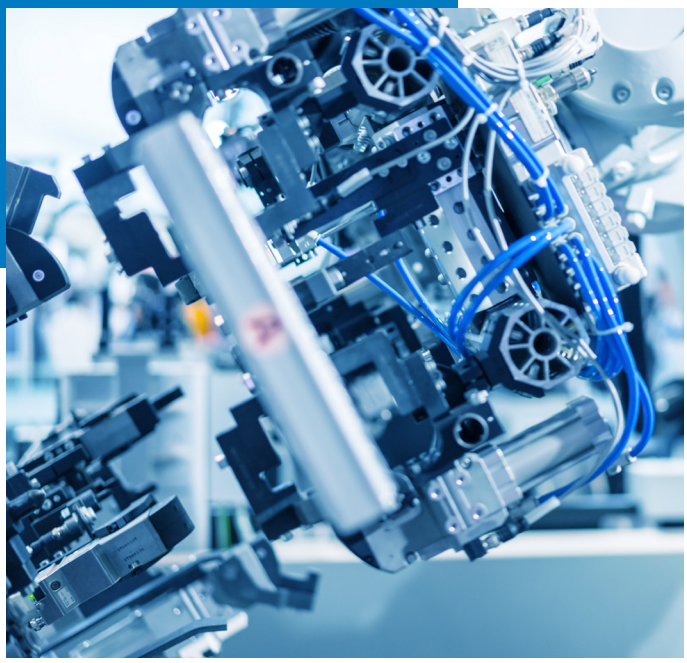


The JMHZ air gripper is designed for use in robot arms.

“ With robots and cobots, product development is all based around two things. Firstly, optimizing the size of a robot according to its payload - the lower the payload, the lower the cost. Secondly, speed and flexibility. SMC is always looking for ways to make robots lighter, smaller and more efficient. We develop all our products based on feedback - actual customer requirements, based on the challenges they are facing. ”

Peter Humphreys, Product Manager, SMC UK

Wireless robots



With wireless, of course, we generally think about the reduction or elimination of cables. But wireless operations are also about increased freedom of movement, especially in multi-axis motion applications.

Continual robotic movement can damage standard cables and, in cases where lots of cables need replacing, the production line may be halted for several hours.

Effective wireless robotics is about communication between the base system and the remote devices. But how is this possible when you have one or two hundred high-concentration machines in a single factory setting? Achieving this by conventional means would require a high number of inputs and outputs (I/O), requiring more cabling with potential for electrical noise and harmonics in the controller signals, as well as crosstalk between the controller and the robots.

A better answer lies in a special proprietary protocol implemented by SMC, which uses the principle of frequency hopping on the same bandwidth as Wi-Fi but with superior performance. Rather than rely on a high number of I/Os, frequency channels can be assigned to wireless systems in the factory process to avoid crosstalk between the different signals. The result is that engineers and technicians can operate four or five robots from a single base controller.

SMC has also provided smaller, more robust systems with fewer I/Os that has yielded productivity benefits in smaller production systems, like in the automotive industry, that don't require programmable logic controller (PLC) environments. Packaging, food and beverage applications can also benefit. The system not only reduces cabling, it makes systems smaller to reduce their footprint and is much faster. It avoids the electrical noise and harmonics associated with standard controlled robotic movements, the frequency interference common in welding and damage to cables from repeated motion.

And, of course, the system's ease-of-use means that you don't need specialized IT people. It is a more robust concept.

> *"SMC is a unique supplier of wireless solutions to drive pneumatic, digital and analog signals. These satisfy needs to reduce or avoid cabling, and the requirements come from applications involving mobile devices. These experience such issues as breakage due to cable frictions, that can produce major machine faults and lead to downtime or lost production."*
>
> Andrea Trifone, Project Manager Mechatronic & Network, SMC Italy

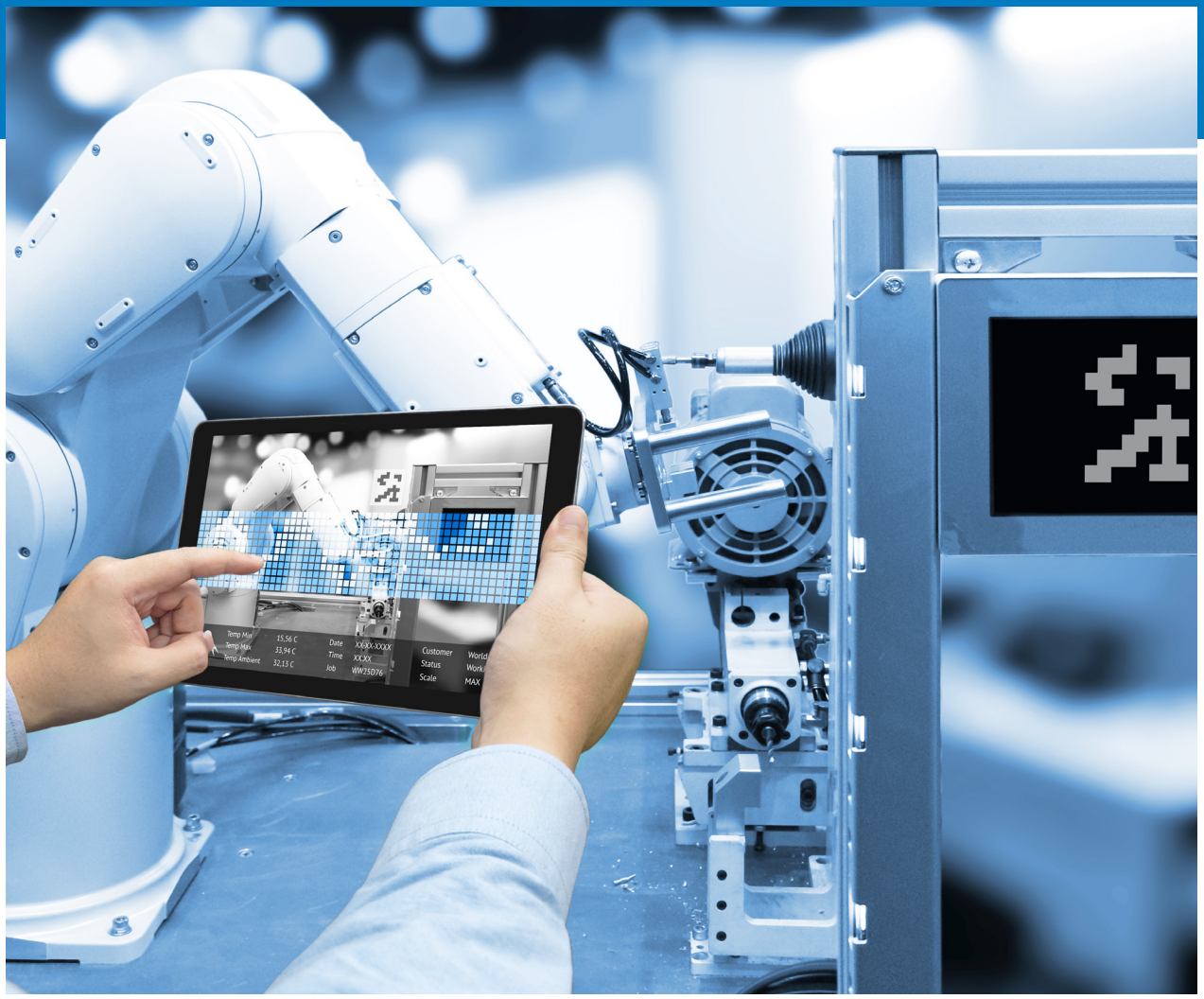
Industry 4.0

Terms like the Internet of Things (IoT), smart sensors, cloud analytics and more are becoming more accepted by manufacturing leaders. But where does this leave robotics? Actually, SMC sees a strong interconnection between the two - for instance, 24-hour production systems, like lights-out manufacturing, could not exist without robots.

Meanwhile, collecting and analyzing data offers advanced services that help users to derive optimal performance from installed robots. It is possible to digitally set the force and position of the grippers and their monitoring. But how can operators and end users access this data?

One way is with IO-Link, the protocol that makes sensors and actuators more intelligent. In short, IO-Link offers new options for communication between the system control and field level devices. Sensors and actuators become active process participants in an end-to-end automation network. As senders, they independently report errors and statuses to the control. As receivers, on the other hand, they receive signals and process them.

The result is cost and process optimization throughout the entire supply chain, across all industries. Big data can be shared more effectively with upper level management, while aiding energy savings through smart, intelligent products.



Advancements in AI

Artificial intelligence (AI) is on the rise in automation and manufacturing and, as with the wider Industry 4.0, promises new connections in industry.

Machine learning software can help robotic systems adapt to their work environments, rather than designing every aspect of the environment and processes to suit the limitations of the machines. These advances will enhance both productivity and safety, and subsequently lead to more applications involving true collaboration between humans and robots.

With more and more connected systems featuring advanced sensor technology, AI can identify patterns in the data that are associated with breakdowns and other mechanical issues. This data will drive predictive applications, where AI can detect patterns that indicate a robot needs maintenance soon. It can automatically alert engineers to take necessary steps towards repairing a machine before it breaks down, sparing companies from costly unplanned downtime that adds an element of unpredictability into forecasting and planning. This includes maintaining robotic systems, as the ability to pre-empt faults allows the planning of downtime for some of the system maintenance.

AI-powered analysis of this data could also help businesses optimize their processes to improve quality and reduce waste. We also see machine learning being used by robots to teach themselves how to perform tasks more successfully. Ultimately these advances will lead to robots sharing that knowledge via the cloud, allowing robots to learn from each other, which will improve the effectiveness of new and existing robot deployments.

Robots in the smart factory

Robotic solutions are now part of 24/7 interconnected systems, sometimes referred to as Internet of Things, Services and People. Collecting and analyzing data can help users to get the most advantage out of their installed robots – as an example, by digitally programming operational parameters.

Zdenek Velfl, Business Consultant CZ & SK, SMC Industrial Automation CZ s.r.o.

Robot and cobot technologies have an important role in the smart factory approach, and both are largely used thanks to their high-level of performances, flexibility and productivity. SMC has developed a wide range of products and solutions compatible with different technologies, such as air and electrical. Furthermore, we listed to market-users' demands to develop custom solutions based on their specific technical requirements.

Andrea Trifone, Project Manager Mechatronic & Network, SMC Italy

Cobots

The global market for collaborative robots, or cobots, is expected to grow at a compound annual growth rate (CAGR) of 41.8 percent until 2026, according to research by MarketsandMarkets. Through our continued work with OEMs, machine builders and end users, SMC is finding that the latest knowledge in the field of robots and their applications can also be applied in the field of cobots, which are emerging as a significant force in the market for industrial automation.

Although the number of cobots installed in the field still generally lags behind the number of installed industrial robots, discussions about the merits of stronger and easier-to-use units – and their potential problems – are still ongoing.

So, why now? One prevalent factor is that businesses want to find new ways to cost-effectively automate their production, while increasing productivity across their applications. Moreover, a project applied successfully for a customer in one country, or one plant, is very likely to be also adapted by other premises or countries in the group.

SMC's answer to the rise of the cobots is its development and launch of new product ranges, such as the JMHZ series of grippers and JSY series of valve blocks. These systems have maximum gripping force and flow, while maintaining minimum dimensions and weight. Another example of development is the deployment of modern technology and valve block control via wireless communications. These developments align with the aforementioned requirements and challenges of industrial applications.

> *“One of the key points of collaborative robotics is the possibility to reuse the cobot for different applications. This degree of flexibility is becoming more important to our customers every year. For instance, a cobot used for a screwdriving task could be repurposed, and the robot hand redesigned, for pick and place applications further down the line. SMC offers a multitude of technologies - pneumatics, vacuum, electric and more - to support this flexibility.”*
>
> Alejandro Molinero, Product Manager and Cobot Specialist at SMC Spain and Portugal

Global Cobot Project

Started by SMC Japan, the Global Cobot Project was formed in response to a single main challenge: how we can utilize cobots for a growing number of applications. How can systems like SMC and Universal Robots’ MHM magnetic gripper – a plug and play kit that installs on the arm of the robot, and better handles ferromagnetic workpieces than vacuum systems or mechanical grippers – be applied in different industries? And where is the future potential for end-of-arm tooling solutions like electric, vacuum or magnetic grippers?

Despite being around for a relatively short time, cobots are a huge, growing market. They might be smaller and lighter with less reach, but with SMC-supplied vacuum, pneumatic or electric grippers, cobots offer a valuable extra hand to manual workers. Electric actuators are so accurate nowadays that cobots – or smaller robots – can be mounted on these to increase their reach. The result is a small-yet-useful, lower cost package.

Peter Humphreys, Product Manager, SMC UK

Plug and play

SMC realized that the goal of a robot arm that can work with a human, hand-in-hand, is best achieved through collaborations with robot manufacturers.

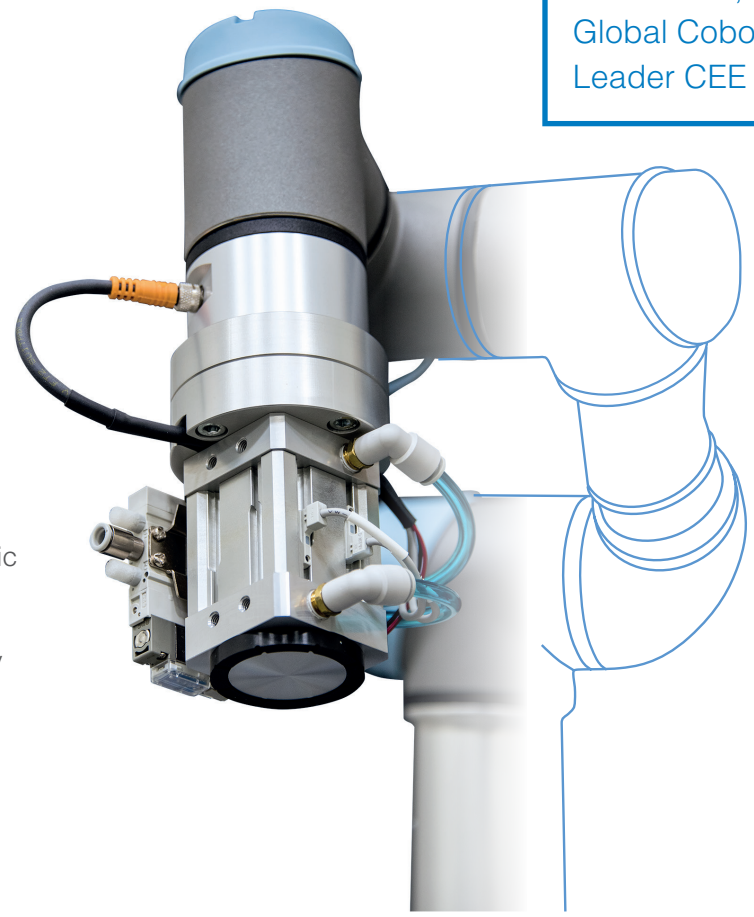
One of our partners is Universal Robots. Founded in 2005, Universal Robots makes robot technologies accessible to all by developing small, user-friendly, reasonably priced and flexible industrial robots that are safe to work with. Universal Robots has been involved with cobots since the launch of the first, in 2008, and the company's ethos felt like a natural fit for SMC.

Our collaboration has resulted in the MHM magnetic gripper kit (shown below). These products are UR+ certified, which means they are verified to work as a plug and play integration with cobot systems. The grippers are designed for handling damage when traditional methods of vacuum systems or mechanical grippers are not viable.

The system does this by instead using a magnet. The MHM kit is designed for flexibility, easy integration and fast operation in packaging, assembly, pick and place, computer numerically controlled (CNC) and machine tending applications. Simply mount the adapter plate and MHM Magnetic Gripper with the valve assembly to the robot, connect the cable to the UR port and connect your air supply line.

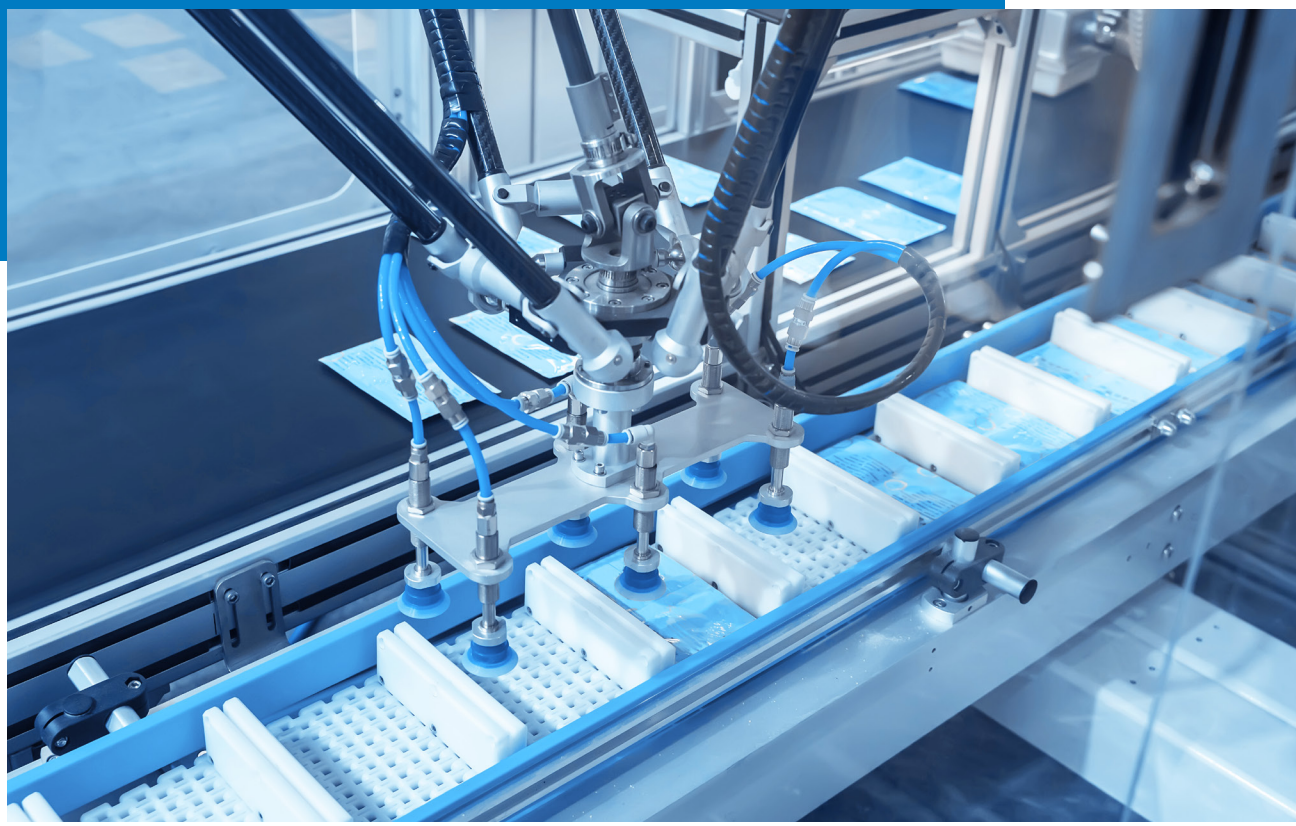
SMC and Universal Robots' other developments for plug and play robotic systems include the JMHZ series of grippers. Also, a vacuum gripper that can be easily-programmed with dedicated URCap software, and is operated by simply connecting one compressed air supply tube and an electrical wiring M8 connector used with industrial sensors.

> *"Robots will never replace the human ability for strategic thinking, invention and detail. Yet, the two can work hand in hand."*
>
> Andreas Czezatke, Expert in Robotics, SMC Austria Global Cobot Project Leader CEE



An MHM magnetic gripper kit, developed by SMC in collaboration with Universal Robots.

Picking and packing



In February 2020, the autonomous mobile robots in parcel giant DHL's plant in Hanover, Germany, recorded a milestone: more than 100 million units picked. This made DHL the first company to reach this mark in the warehouse AMR industry's history. In the three years since DHL first piloted the technology in 2017, what once seemed like science fiction had radically transformed its operations.

Retailers of all types will begin factoring automated piece-picking into their order fulfilment strategies as they seek the right mix of 'bricks and clicks' and build a distribution network that balances micro and macro, local and long haul. Worker productivity will skyrocket as individuals begin to supervise growing fleets of robotic pickers.

This automated piece-picking capability will drive down costs for a range of fulfilment models, including those managed by third-party logistics providers. This will in turn preserve margins as retailers compete to provide consumers a better overall experience, with buying options that are increasingly fast and convenient.

Delta robots, upside-down robots and vision systems are being used for palletizing and boxing, small assembly and cutting in food and beverage applications. SMC components like high-speed valves are essential to such fast, continuous manufacturing with high levels of throughput.

As for SMCs components that go into the robots, lifetime expectancy is critical – but you can't legislate for what you can't see. That's why smart sensors and IIoT connectivity are so essential in these applications to regularly check the health and operation levels, and that robots are picking up products continually.

Peter Humphreys, Product Manager, SMC UK

The future

Going forward, SMC expects to see a trend of manufacturers seeking to do more and more with robots. This is particularly likely as cobots present greater possibilities for cooperation and collaboration with humans.

Smaller companies are open to the use of cobots because of their speed and smaller sizes, but also lower prices. SMC anticipates that automotive will remain the primary area of growth for cobots. However, their appeal will also go beyond automotive into other sectors where we expect a principle use will be for mounting on production lines.

We also see growing potential for cobots in automated guided vehicles (AGVs), as used to pick and move products in warehouses or around the production line. Another is the use of cobots to operate and tend to CNC machines, a new and dynamic area where SMC anticipates high expansion in the future. There are also growing possibilities in welding applications. And, finally, we will see greater flexibility in how existing cobots can be repurposed for new end uses in the production line.

The possibilities of robotics will continue to leap from the pages of science fiction into reality, as demonstrated at the CES 2020 tech exposition in Las Vegas, Nevada, US – always a showcase for weird and wonderful technologies. A robotic exoskeleton worn by workers, which allows the average person to manipulate heavy loads over 100 pounds, and a “human partner robot” by Toyota that is controlled by a human operator wearing a virtual reality (VR) headset were among the exhibitions.

Truly, Isaac Asimov would be proud.

“I personally expect robots and cobots to increase their market share over the coming years as interest in the smart factory concept continues to grow. Many companies are setting up different levels of knowledge and skills to properly manage Industry 4.0. With more innovative, compact and flexible components - alongside innovations like sensors or Wi-Fi - robots can help to drive these global markets and global competition.”

Andrea Trifone, Project Manager Mechatronic & Network, SMC Italy

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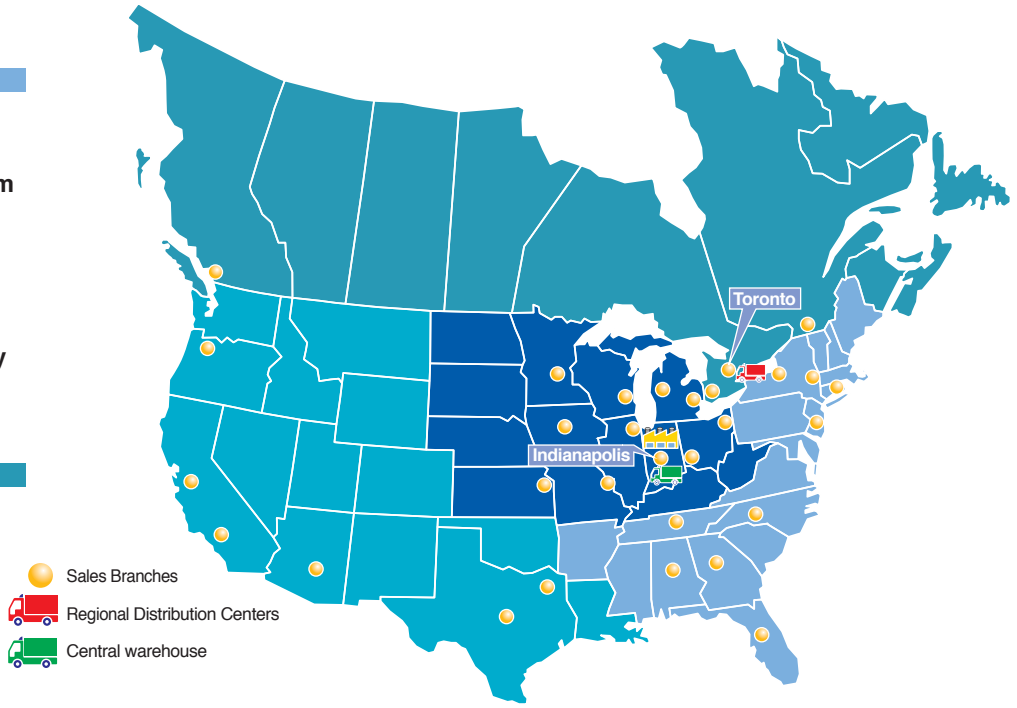

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