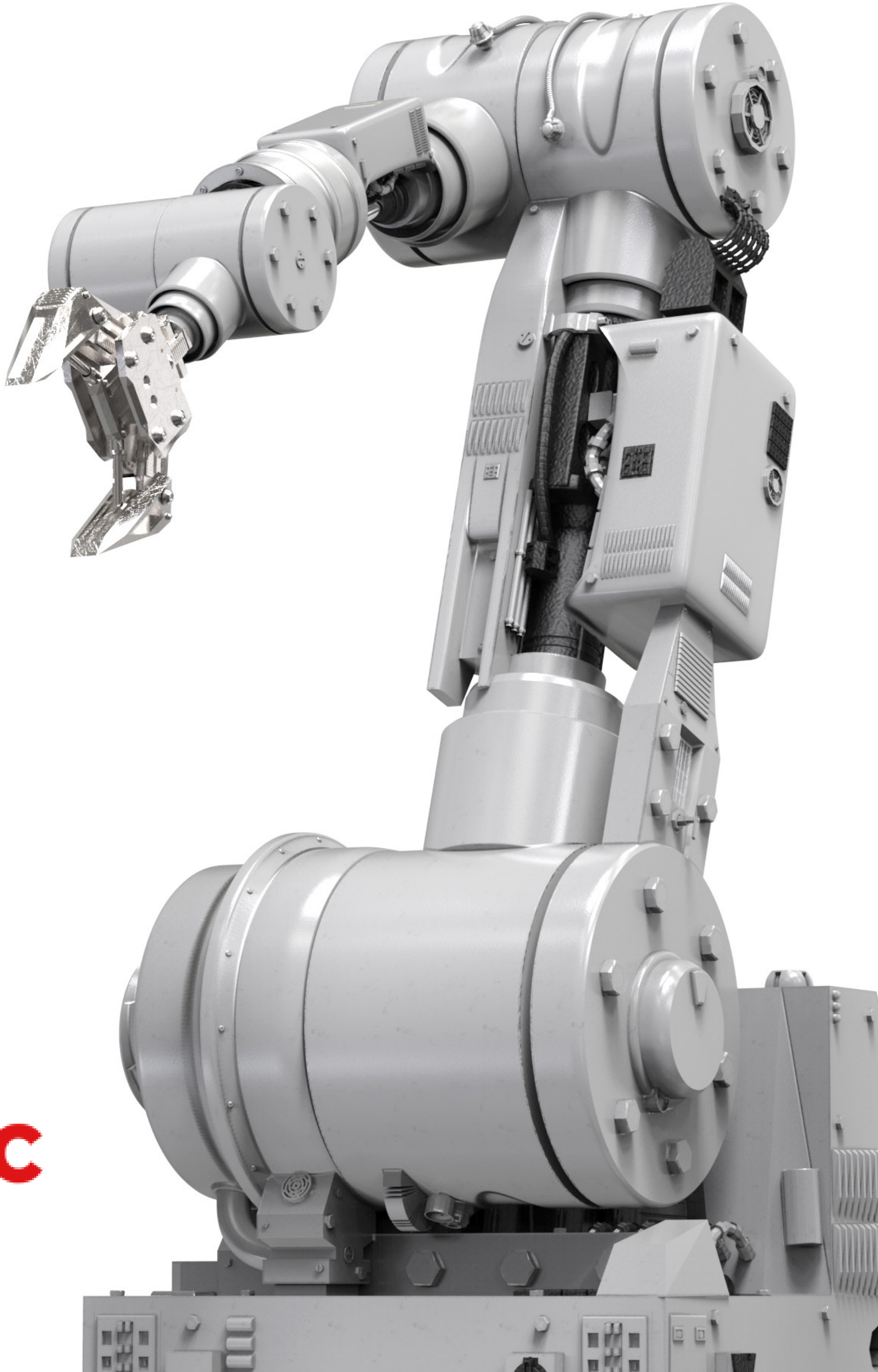
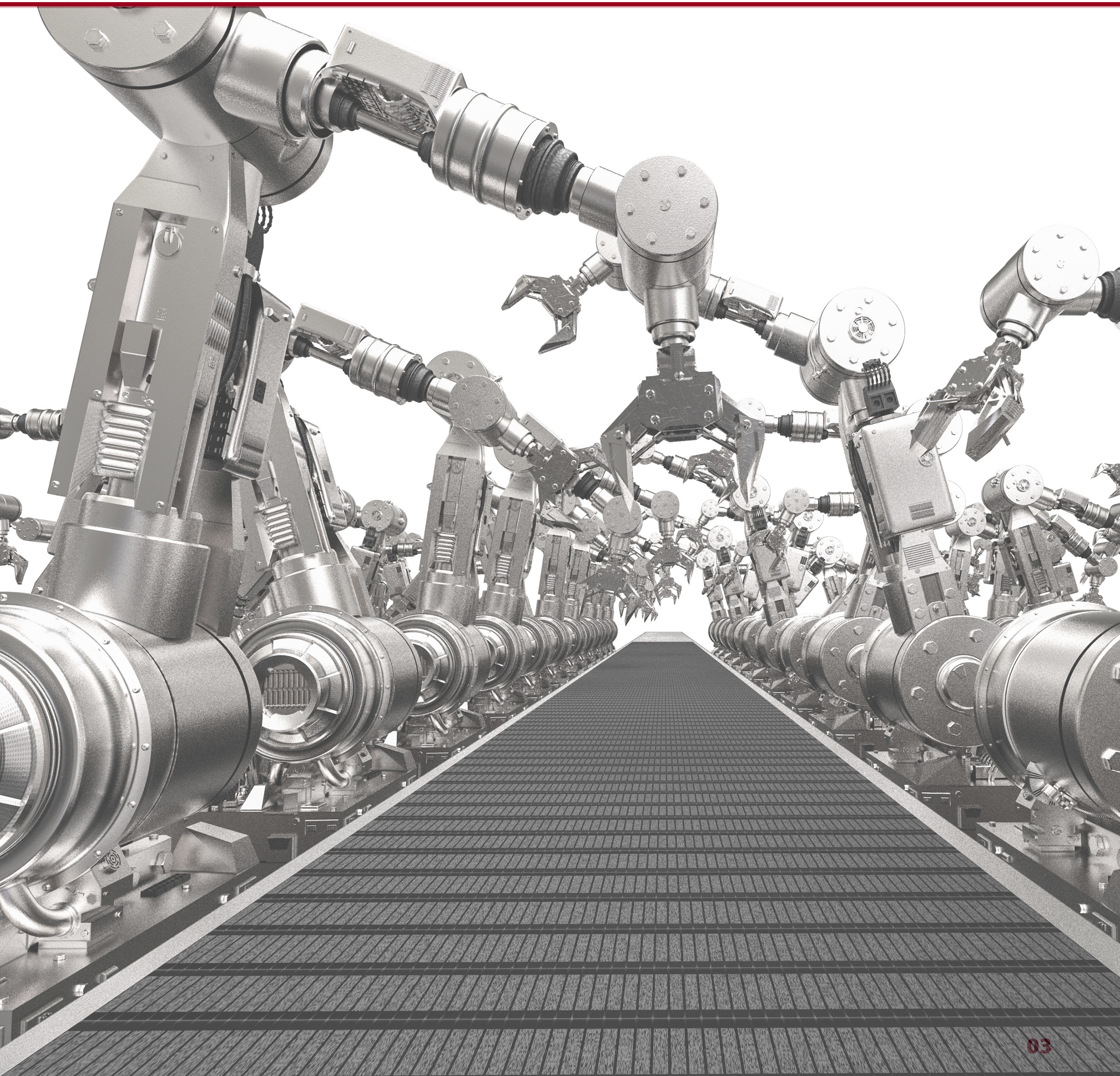
ISSUE 2, 2023



A GUIDE TO ROBOTICS AND AUTOMATION

DISTRELEC



WELCOME

We published our first edition of the Robotics and Automation Guide back in January, introducing the reader to the world of robotics. Our main focus was to describe the history and evolution of robots and explain the nuts and bolts behind robotic systems. We laid the foundation for the reader's understanding of how robotics work and why they will become an increasingly important part of our society. Now it's time to delve deeper.

In some industries, robots have been used to streamline workflows and processes for years, but some disciplines are lagging behind, due to a variety of factors. However, opportunities to implement robotic automation systems are growing in industries such as logistics and agriculture, and more affordable options are starting to allow SMEs (small and medium enterprises) to get in on the action.

As a distinguished distributor of electronics, Distrelec ensures that it stays ahead of the curve when it comes to the latest trends and innovations in the industry. We believe that passing that expertise down to our customers to help boost productivity and efficiency is crucial.

To help us accomplish this, we've prepared the second edition of our Robotics and Automation Guide. You'll be able to discover how robotics are a key part of the industrial revolution through network connectivity and how they can be embedded into certain workflows and ecosystems to simplify the process and increase efficiency.

But is society fulfilling the potential of robotics and automation? Or can more be done? Read our latest Robotics and Automation Guide to find out.

Raj Patel

Managing Director

DISTRELEC

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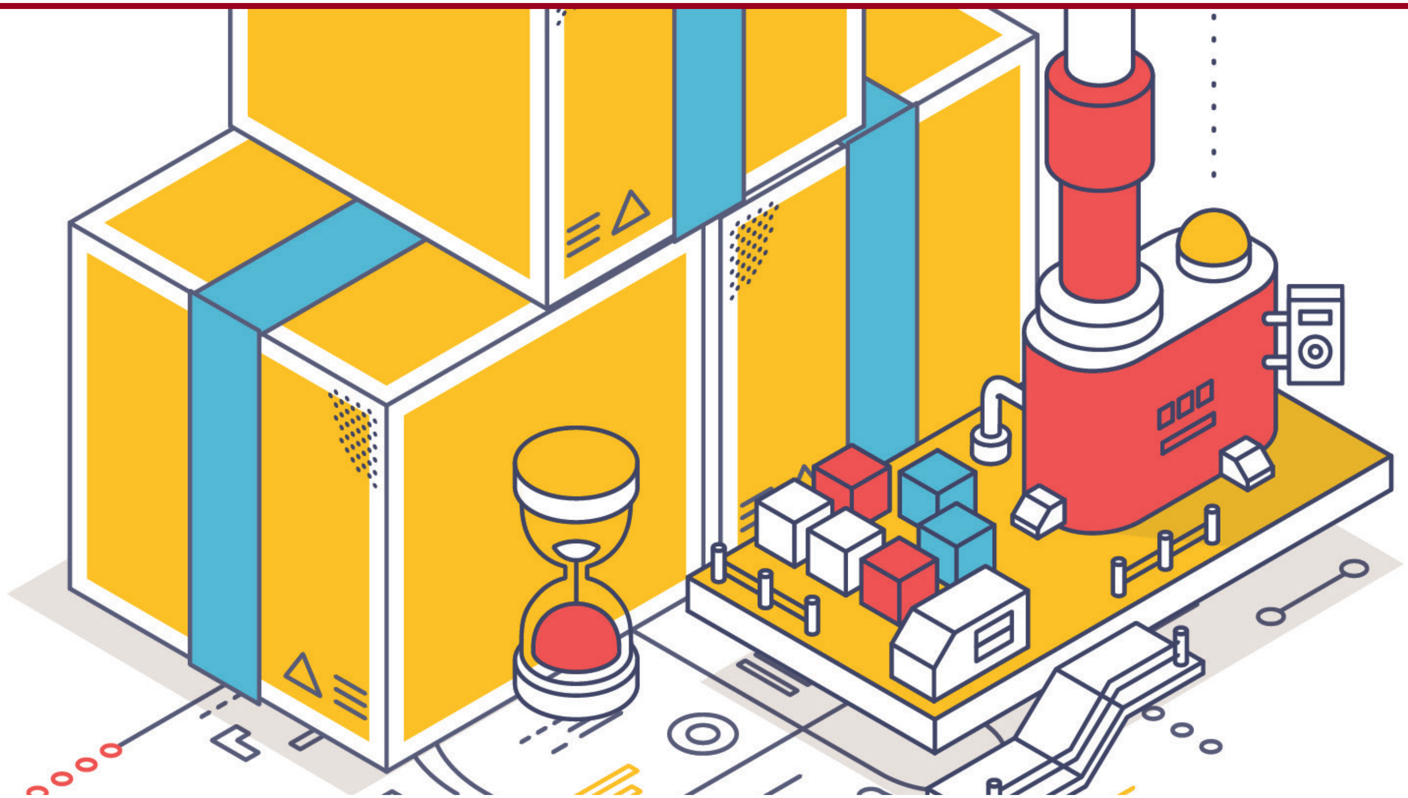
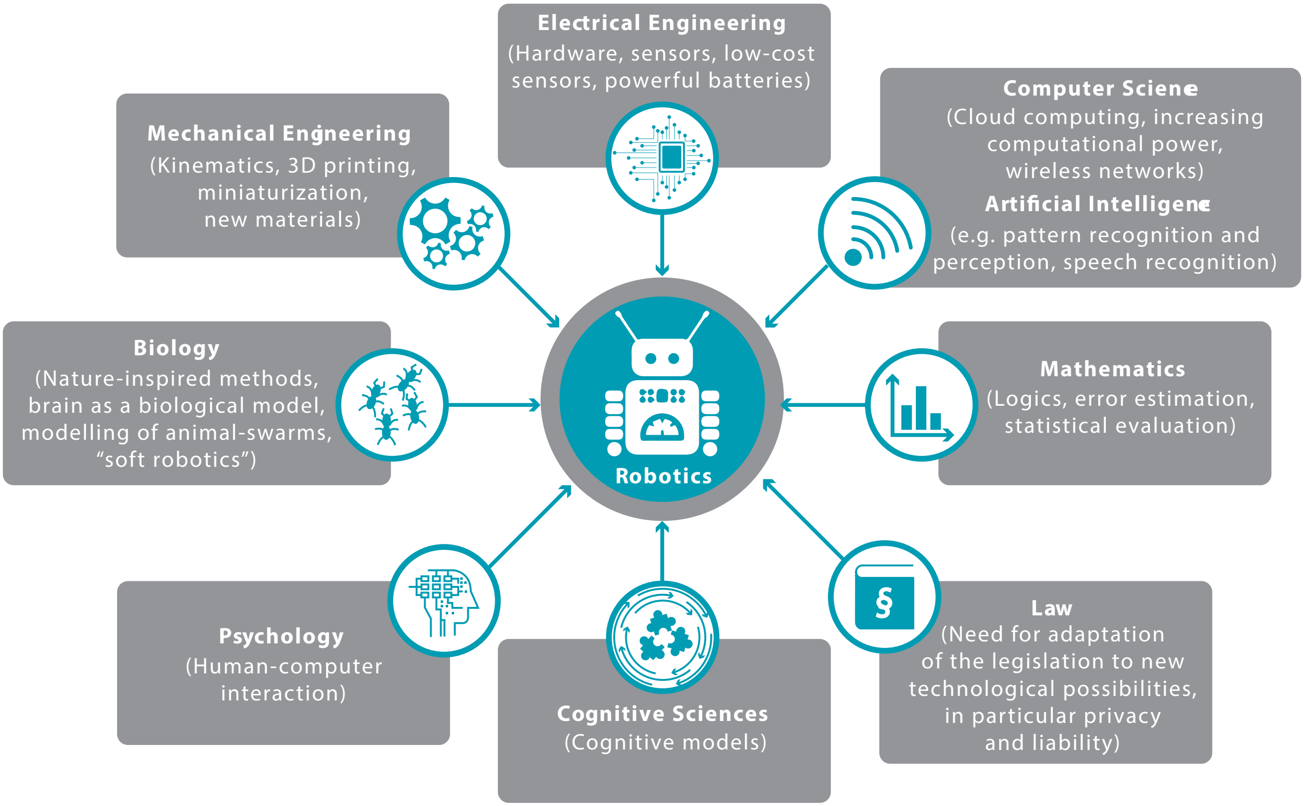


Beyond Manufacturing – Robots and the Supply Chain

How robotics can support faster, safer and more productive logistics.

While commonplace on the manufacturing side of the supply chain, to date robots have seen limited adoption in the logistics sector. A key reason for slow uptake has been the commercial viability of technology to address the complexities of the challenge – complexities that include handling a wide array of different parts in an almost infinite number of combinations, safety implications of humans and robots collaborating in the same space, and the prohibitive cost of hardware and computing power.

Now, however, the situation is changing and advanced robots are starting to enter our warehouses and sorting centres, even helping with 'final mile' delivery to the end customer. DHL, a company that is actively engaged in the deployment of advanced robotics, is well placed to consider the latest developments and how they will help to deliver logistics supply chains that are faster, safer and more productive.



Advanced robotics is a complex, multi-faceted challenge

ROBOTICS IN LOGISTICS – THE TIME IS RIGHT

The main reason for the lack of logistics robots is that, until recently, robots have been simplistic – performing the same movements over and over again, albeit with a high degree of accuracy and precision. For many simple manufacturing processes, such as welding or transferring parts, these skills are all that is needed. Logistics, however, requires a robot with more versatility and ability.

Labour availability is a significant challenge for the logistics industry. More workers are needed due to the growth in e-commerce and the need to move from bulk pallet shipments to individual packages that are shipped to consumers. This drives more cost and labour per item sold. In the Western world, the challenge of finding and hiring labour is exacerbated by shrinking populations, which reduces the available workforce.

Given these challenges, robotics has moved from being 'nice to have' to being a necessity for the future of the logistics industry.

ENABLING TECHNOLOGIES

A robot that is effective in supporting logistics operations will need to have some form of 'eyes', 'hands', 'feet' and 'brain'. It will need eyes to see an object, hands to pick it up, feet so that it can move the object to another place, and a brain capable of coordinating all these tasks.

Creating 'eyes' requires more than just an image sensor or camera; sophisticated machine vision software is required to interpret the data. For example, when picking from a bin the robot has to identify a single part from many, even if the item is partially obscured. The robot then needs to plan how to move its arm and hand to pick the item up.

To address this challenge, Universal Robotics uses a Microsoft Kinect sensor and its Neocortex software to mimic the human brain. Using this approach, a robot is trained to pick up a specific item and this knowledge is then transferred to other robots.

Meanwhile Schunk designs and sells robotic grippers. Its latest hand follows nature, mimicking the human hand with five fingers, twenty joints and nine motors. Weighing only 1.3 kg, this robotic hand can pick up heavy tools with a 'power grip' or delicate electronics with a 'precision grip' – just like a human hand. Robotics that replicates human hands may be the key to giving robots the flexibility needed for the logistics world.

Enabling logistics robots to move around a warehouse, sorting centre or even a town requires advances in technology such as omnidirectional wheels that can move a robot in any direction without turning.

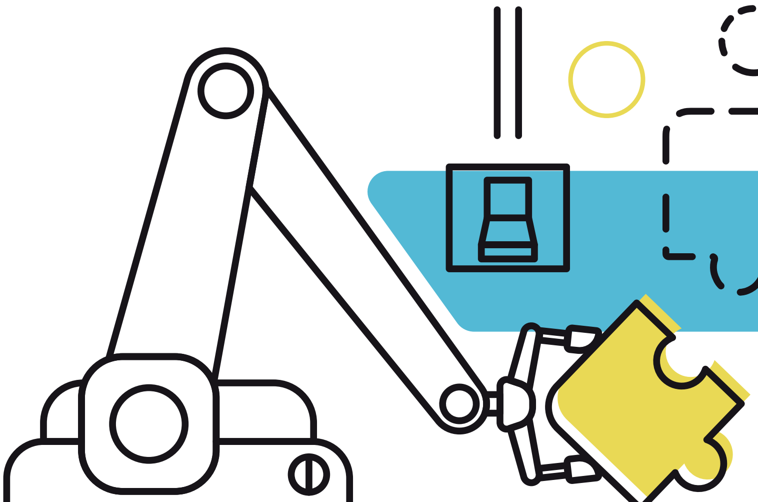
The all-essential robotic brain would need unprecedented computing power to replicate the human brain. As robots will be dedicated to a limited task set, the computing power can be reduced. Technology is moving in the direction of cloud processing where robots would transmit images to, say, Google, allowing their powerful computers to identify an object and return information on how to pick it up.

NEAR-FUTURE LOGISTICS ROBOTS – SOME USE CASES

Containers are a very popular method for ocean shipping of goods from factories and, to save on transport costs, they often arrive stacked with goods from floor to ceiling – without pallets. As early as 2003, DHL developed a Parcel Robot that was capable of using a laser to scan the container contents and then unload the container onto a conveyer belt in an optimal sequence.

On the other hand, mobile piece-picking robots move to fixed shelves to retrieve goods. Fetch Robotics is one example where a primary robot ('Fetch') can extend its torso to reach items on high shelves and pass them to a second robot ('Freight') that holds a tote for the item. The Fetch robots operate in a single aisle, while the Freight robots are more agile, moving around the warehouse to where goods are located.

Co-packing robots, such as 'Baxter' from Rethink Robotics, work alongside humans to perform tasks such as unpacking



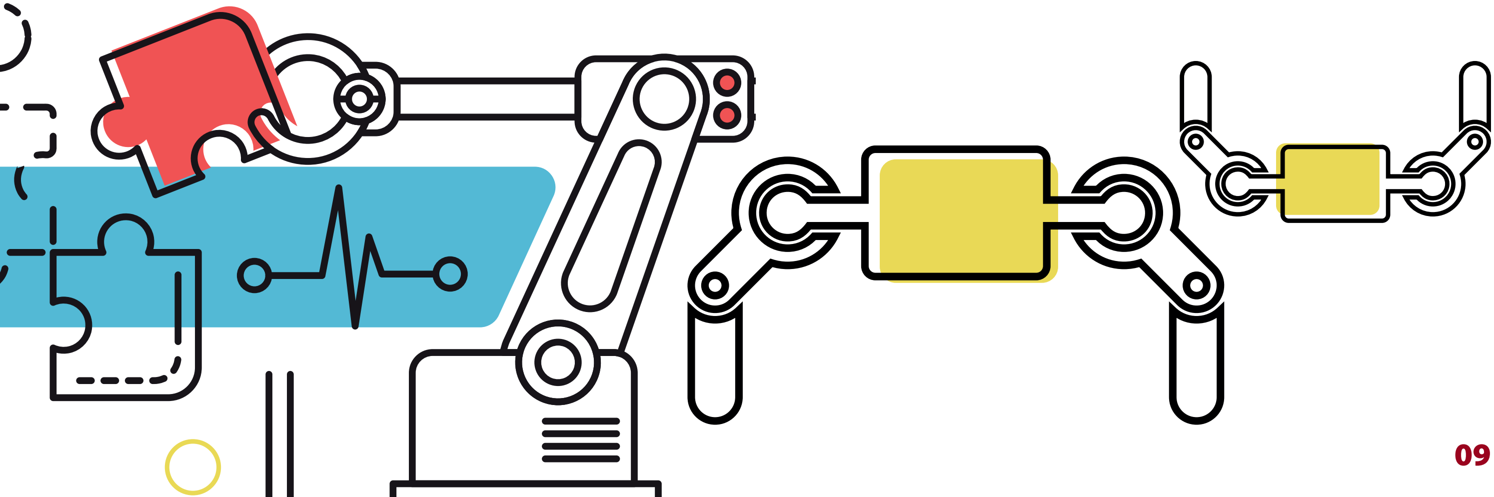
boxes, adding promotional labels and then re-packing the boxes. With spring-loaded joints and sensors to detect when it touches an object, Baxter is safe to operate with humans and is trained by grabbing an arm and leading it through a simple task.

SSI Schaefer's Robo-Pick uses an automated tote system to move goods to a stationary robot that identifies the required item, picks it and deposits in onto a conveyer belt. This system is claimed to be able to pick up to 2400 items per hour and works best with smaller items such as DVDs or pharmaceuticals. More sophisticated versions can place the picked item into a final shipping box.

The final frontier for logistics is taking the robot outside of the warehouse to perform the ultimate delivery steps to a home or business.

An early example of this comes from Starship Technologies, whose autonomous robot can carry two grocery bags arriving at an address at a precise time. Recipients can track progress on a mobile app and use the same app to unlock the robot and retrieve the goods.

One of DHL's robots is capable of optimally loading a shipping box with packages (courtesy of DHL Express)



Agricultural Robots - Bringing Smart Automation to Farming

While automated agricultural equipment technically dates back a hundred years, true agriculture-focused robots only became viable towards the end of the 20th century. It is the significant advancements in computing power and machine vision in particular that have now made robots practical within an agricultural context.

As the name suggests, agricultural robots are deployed for various farming-based jobs. They can be assigned to perform repetitive and physically grueling duties, instead of human workers. In addition, they can be used for carrying out more niche-specific agricultural tasks. According to BlueWeave Consulting, the global agricultural robotics market is set to see huge growth in the coming years. It is projected to reach annual revenues of $81 billion before the end of the decade.

This section of our robotics guide explores the rising popularity of agricultural robots. It looks at the applications they are being targeted at, as well as the challenges involved in their implementation.

WHY USE AGRICULTURAL ROBOTS?

Similar to any industrial machine, the robots employed in agriculture enable dramatic operational improvements to be realized. Consequently, farmers can increase overall efficiencies and augment the production yield of their land.

Other advantages of putting robots to work on farms include:

- Farm deployed robots make fewer errors and operate at higher speeds than human workers can.
- Agricultural robots that feature weed and pest detection sensors allow farmers to lower pesticide usage, which thereby has ecological benefits. These intelligent machines ensure that spraying only needs to be done on affected areas, which can make farms relatively chemical-free.
- Much like other industrial robots, agricultural robots can operate right around the clock, with only minimal maintenance being needed. This reduces the dependence on human labor and curbs the overall cost of food production.
- Some agricultural robots can be equipped with various kinds of end effectors to make them more versatile and enable them to perform multiple tasks. This means that the investment needed can be spread more widely.
- Overall farm automation is making supply chains more efficient, ensuring minimal food wastage and greater profitability. This has the potential to lead to lower prices for consumers.

Despite all these plus points, there are still a few issues that must be addressed from a technological standpoint before agricultural robots will see widespread adoption. These will be outlined later.

APPLICATIONS OF AGRICULTURAL ROBOTS

So, what kind of agriculture-based tasks are robots able to perform? Here are a few key examples.

- **Crop Seeding** - The traditional method of planting seeds by scattering them can be less than optimal, with crop yields being detrimentally affected. Instead, autonomous seeding (helped by geo-mapping) ensures that the seeds are dropped at exactly the correct places and depths.
- **Horticulture** - Agricultural robots are of value in horticultural work, for the cultivation and delivery of potted plants. Among the numerous solutions for this is the one from Dutch firm, WPS. It offers smart picking and placing capabilities through its intelligent robotic arm, which is equipped with multiple sensors.
- **Irrigation and Fertilizing** - Precise irrigation systems aided by automation can significantly reduce water wastage. Though still in the research phase, agricultural robots have shown promise in traversing rows of crops and accurately sprinkling fertilizer or water on them.
- **Harvesting** - Picking crops is a repetitive process that is well suited to robots. It means that agricultural operations do not have to deal with the difficulties of recruiting seasonal workers (which in many countries

are proving increasingly hard to find). It must be noted, however, that picked produce will need to be handled carefully, so as to prevent damage (otherwise there will be increased wastage levels to factor in). One company that specializes in harvesting strawberries is Harvest CROO. Their robots are designed to scan and determine the ripeness of berries and then pluck them without causing them any harm.

- **Weeding** - Weed control is always a challenge, with plants developing pesticide resistance and heightened consumer demand for organic food where only minimal chemicals have been used. Fortunately, certain agricultural robots are resolving this problem. The Ted robot platform specifically caters to vineyards, and works by distinguishing between crops and weeds, before mechanically removing the latter. It is easy to operate and highly accurate. Most importantly, with help from this technology, farms can avoid any use of herbicides.
- **Crop Health Monitoring** - Sophisticated drones set up with camera sensors and featuring AI can identify diseases in crops. Through this, farmers are able to conduct early interventions. Equinox Drones represent an example of this. These offer access to real-time imagery for early disease assessment in crops. In case of crop damage, they also provide valuable information to help farmers take remedial measures in the future.
- **Phenotyping** - Phenotyping in agriculture is the process of measuring and understanding the characteristics of crops (such as resistance, growth, yield and adaptation). This procedure helps in improving their traits with respect to future plant breeding. Robotics in phenotyping is a relatively new field, but several robotics systems are showing their effectiveness in measuring chemical and physiological characteristics of various plants over time. A Belgian company WIWAM has a series of phenotyping robots that allow for non-invasive imaging of plants.

Challenges for Agriculture Robots

Though this all looks encouraging, there are still some obstacles that need to be overcome. Researchers from Monash University have been among those who have questioned 'smart farming' methods, and the use of robotics in agricultural work. They have expressed concerns over damage to soil from heavy robots, as this may cause soil compaction to occur. They also fear that the standardization of the produce could lead to an increasing reliance on genetically modified crops more suited to automated farming.

A lot of electronic components in robotic automation also need to be ruggedized, as they are exposed to varying ambient conditions, with extremes of temperature and moisture experienced. This adds to the overall bill of materials costs. Also, the automation infrastructure required to operate agricultural robots (such as wireless connectivity) may be prohibitively expensive for smaller farms. With time, the cost aspect is likely to be less problematic - as the unit volumes increase, the pricing will become more attractive.

The application of robotics technology in relation to agriculture is advancing at a rapid pace in terms of the technology involved, and this is resulting in ever greater uptake. Via this, there is the prospect of a positive impact being witnessed - not just by farmers and the consumers they serve, but also on the environment, health and society at large.

Making (and Keeping) the Connection

In any complex robotic or automated system, a large number of power, data and signal connections must be reliably made between multiple components and sub-systems.

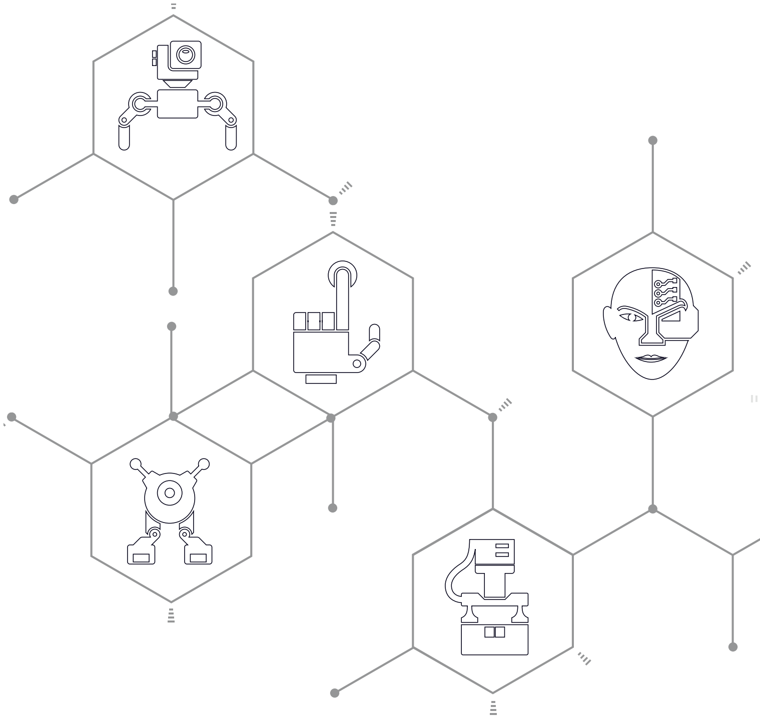
INTERCONNECTION

With thousands of connections, implemented both wired and wirelessly, interconnections must be 100% reliable if the advantages of a long operating life and high efficiency are to realize the cost benefits robotic systems are designed to deliver.

The number of sub-systems that need interconnection is vast and they have many different characteristics. Examples include low-power sensors, both internal and external to the robotics platform, that deliver signal levels in the millivolt range, as well as sophisticated robot hands or 'effectors', with a 'haptic' ability to sense and manipulate objects, and which require real-time data and video streams screened from sources of electromagnetic interference. In addition, connections may also need to deliver high currents in pulsed loads to motors, servos and other electromechanical devices.

Power, data and signal interconnections will often be in close proximity, requiring high-density connectors. Since they will often be routed through the same space or even the same connector there is the potential for electrical interference between systems.

The operating environment will also define the interconnection solution, as parts of the robotic platform could be moving in several axes each creating its own levels of shock and vibration. Other factors to be considered are temperature extremes, water, dust, a corrosive atmosphere, exposure to chemicals, and proximity to hazardous processes such as welding.



CHOOSING AN INTERCONNECTION SOLUTION

Connector options will include circular, rectangular multi-block, data connectors and terminal blocks. With the restrictions in space and a large number of connections, a good option is to use modular connectors that can be semi-customised with a combination of power, data and signal contacts. Manufacturers such as Harting, with its Han-Modular® series of products, allow unique connector configurations by selecting from a range of connector modules, hoods and housings. This approach reduces the overall number of connectors and the overall size of the solution without the need for a full custom connector design.

In robotics applications, there will be situations where parts of the system are moving relative to static parts of the system. This creates torsional stress on the connector and associated cabling, so consideration needs to be given to strain relief for the connector, the type of cable used and the routing of the cables throughout the system.

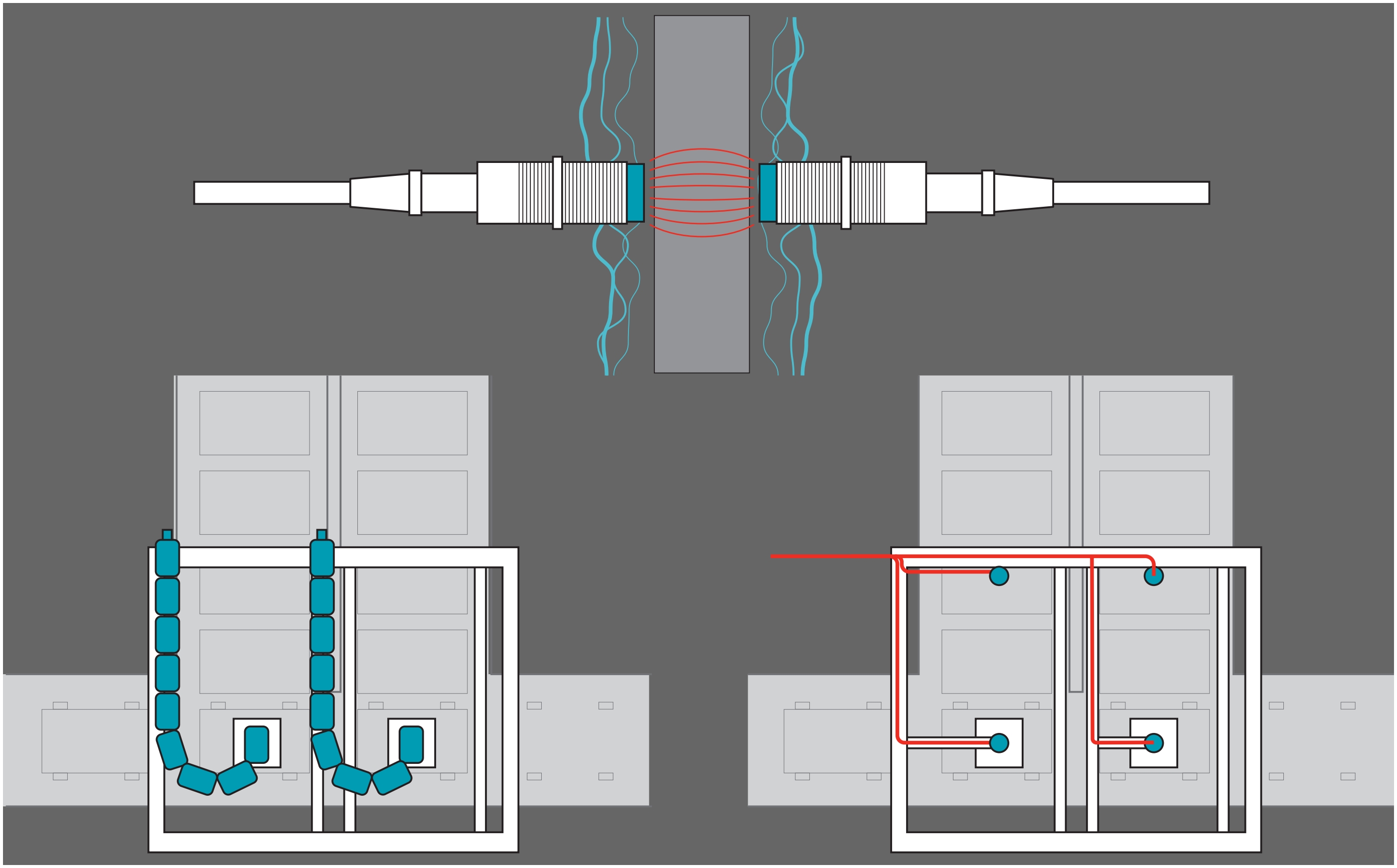
In some cases, parts of the robot will need to rotate, so slip-ring connectors are used to guarantee a high-integrity connection. These are electromechanical parts that solve the engineering problem of providing a reliable connection to a rotating object by transferring power or data through a metal or graphite brush that is kept in contact with a metal ring as it rotates. The electrical resistance is higher than in a static connector solution, but the moving parts can wear and oxidise over time.

Another solution to making contact with moving parts is the contactless Ariso connector series offered by TE Connectivity, which uses an inductive magnetic coupling to deliver power and data without a physical connection, and if necessary through water or oil.

Connectors can also be divided into locking and non-locking types, with locking typically achieved in circular connectors using a threaded coupler, and in rectangular connectors using locking arms.

Non-locking data connectors such as USB are well suited electrically to the transmission of high-speed data but are easily disconnected, and are not suited for harsher environments. Ruggedised versions such as those manufactured by Bulgin can be used that lock and provide protection against exposure to liquids and dust.

The design of the connector contacts is vital for long-term reliability and this is a likely point of failure in non-benign environments. Many connectors have a male-to-female contact arrangement, and the long-term reliability depends on the design of the connector contacts (material and plating) and whether they are lubricated. Bifurcated contact points which allow for redundant electrical paths are recommended in dirty environments.



Cables and connectors can fail over time; contactless connectors can overcome these issues

NETWORKING CONNECTIVITY

Early robots used proprietary networking standards to connect controllers to remote components. In order to reduce costs and deployment times, it is preferable to make use of PCs equipped with off-the-shelf Ethernet networking hardware.

Many people understand the term 'Ethernet' to be the cable that connects their PC to the local area network (LAN) and the internet. In fact, this is only the physical part of the internet, which carries a series of communications protocols such as Transmission Control Protocol/Internet Protocol (TCP/IP) and other protocols that enable communications. This set-up suits consumer applications, but to control any complex process the network must provide three key elements: deterministic, real-time control; system-wide time synchronisation; and precise scheduling.

The IEEE 802.1 working group of the IEEE Standard Association has proposed draft standards to allow time-sensitive networking (TSN) to be conducted over standard Ethernet networks. The new project draft IEEE 802.1Q is aimed at delivering real-time networking for both audio and video applications as well as real-time control for industrial networking.

NETWORKING PROTOCOLS

A number of industrial networking protocols are available to organise the movement of data packages within the TCP/IP architecture.

Ethernet/IP, part of the Common Industrial Protocol (CIP) family (which includes ControlNet and DeviceNet) is an application layer that uses traditional Ethernet protocols including TCP/IP and is compatible with standard Ethernet hardware, meaning it can be easily implemented and should be future-proof. It works by organising data packets in such a way that real-time performance is possible over standard Ethernet hardware, which brings advantages in deployment time and cost. It is well supported by multiple vendors and is popular in the North American market, where it is often used with Rockwell Collins control systems.

Another market-leading standard is EtherCAT, which was created by German automation company Beckhoff in 2003. It focused on achieving a short cycle time, low jitter and low hardware costs. The protocol has been widely adopted by the semiconductor, display and solar panel manufacturing industries including Applied Materials, Lam Research and Brooks Automation, which has given it a significant user base and market share.

EtherCAT uses a principle called 'processing on the fly', which means messages are passed on before they are processed, resulting in high speed and efficiency. This approach is claimed to provide the most deterministic response of any of the Ethernet standard available.

EtherCAT uses an open-software approach combined with off-the-shelf Ethernet master controllers with customised EtherCAT slave controllers (ESCs). The ESCs contain proprietary application-specific integrated circuits (ASICs), field-programmable gate arrays (FPGA) and other microcontrollers programmed with licensed software. EtherCAT hardware is available from many manufacturers, who have made a fairly large investment in design and development. Consequently, they are more expensive than standard Ethernet components.

WIRELESS CONNECTIVITY

In many applications, the robotics systems will be mobile, for example autonomous vehicles or pallet-handling systems in a logistics environment.

It is also desirable in many systems, even if the robotics platform is static, for there to be only power connections made to the system and for the data traffic to the control system to be made wirelessly. This results in less cabling and also more flexibility when re-configuring factory layouts.

Wireless protocols for robotics and industrial automation are still in the early stages of adoption, but will be essential to fully realise a connected network of robots, sensors and measurement devices. When selecting a wireless protocol for industrial applications key criteria will be the required range, frequency and data rate.

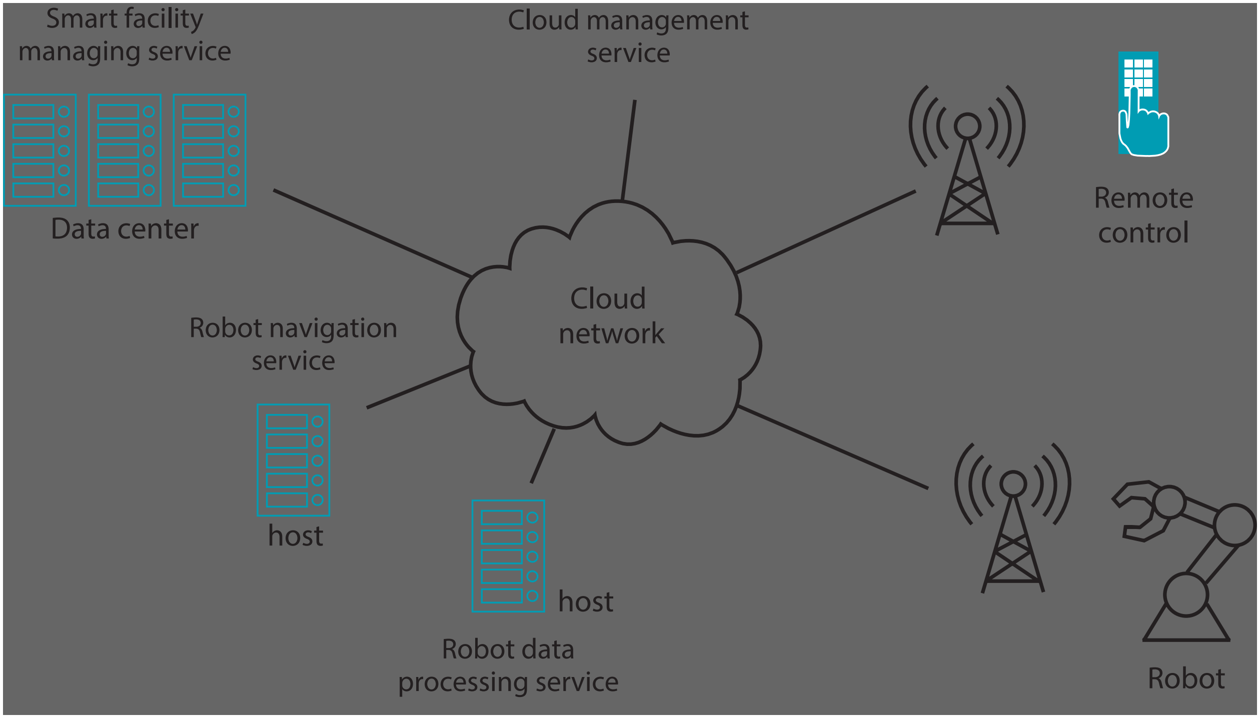
Many common communication technologies are well established in all areas of industry; for example, Bluetooth is often used to replace wired point-to-point connections, and for real-time applications Wi-Fi using protocols designed for industrial use can be deployed quickly, as they have low latency and do not require an external network operator. However, Wi-Fi has limitations such as having very few channels, which can interfere with each other, and it is sensitive to the EMI/RFI that is generated in industrial environments. 4G LTE (cellular) has the potential to enable communications over a range of many kilometres, and has high bandwidth and reasonable latency – but it requires a network operator, with each connected terminal requiring an individual SIM. It should be noted that this SIM requirement will not apply in future. One successful application hotspot is agricultural farm equipment, which uses 4G combined with GPS on large farms with 24/7 operation significantly improving machinery utilisation.

Other protocols that are suited to non-real-time applications such as the deployment of large-scale wireless sensor networks (WSNs) are based on the IEEE 802.15.4 technical standard and include WirelessHART, ZigBee and ISA100.11a.

Protocol	Data rate	Max range	Frequency
4G LTE	50 Mbps	Many km	2 to 8 GHz
5G	Est. 1 Gbps (TBD)	Many km	TBD
Bluetooth	1 Mbps	150 metres	2.4 GHz
IEEE 802.15.4	250 Kbps	75 metres	868/915/2450 MHz
Wi-Fi	1 Gbps	50 metres	2.4/5 GHz
WirelessHART	250 Kbps	225 metres	2.4 GHz
ZigBee	250 Kbps	75 metres	2.4 GHz

Wireless protocol comparison

CLOUD ROBOTICS AND 5G



5G technology, with gigabit connectivity, may negate the need for other types of wireless networks

All of the wireless protocols discussed here are too slow to enable robotics to reach its full potential.

In order to fully realise mobile, autonomous robots that can manage real-time complex processes and make instant decisions the raw processing power would occupy more hardware real estate and consume more power than can economically and physically be incorporated into an industrial robot.

For robotics to reach the next level this processing will be done in the cloud and be driven by 5G networks as the fifth-generation wireless technology will eventually power everything from objects, devices and machines to electric vehicles and power grids.

SECURITY

With the increase in connected systems and with more open standards used in industrial environments, the risk of security breaches, both intentional and accidental, will increase. Networks will need encryption, devices will need to be authenticated and critical areas and infrastructure will need security control.

In March 2017 it was reported that security researchers successfully hijacked a 100 kg robotic arm manufactured by ABB by inserting a USB stick containing malicious code. The robot, equipped with gripping claws, welding tools and laser capability, had serious potential to damage the manufacturing process and pose a danger to factory operators.

Robotic systems are some of the most complex in existence, operating in difficult and challenging environments.

KEY FACTORS TO CONSIDER

01

How many power, data and signal connections are needed for each sub-system? What are the electrical, EMI screening, space, weight and environmental considerations?

02

When choosing the interconnection solution consider the design of the connector contacts, whether a locking connector is required, whether dust or waterproofing is a requirement, and whether a modular connector with a combination of power, data and signal contacts would be a space-saving option.

03

To control a complex process the networking connectivity solution must support real-time control, time synchronisation and precise scheduling. Ethernet/IP and EtherCAT are both popular protocols to consider.

04

Industrial networking protocols combined with TCP/IP architecture and off-the-shelf Ethernet networking hardware provide a cost-effective solution for robotics and industrial control.

05

A number of wireless connectivity protocols can be deployed for robotics applications, depending on the application, required data rate, range, frequency and environment.

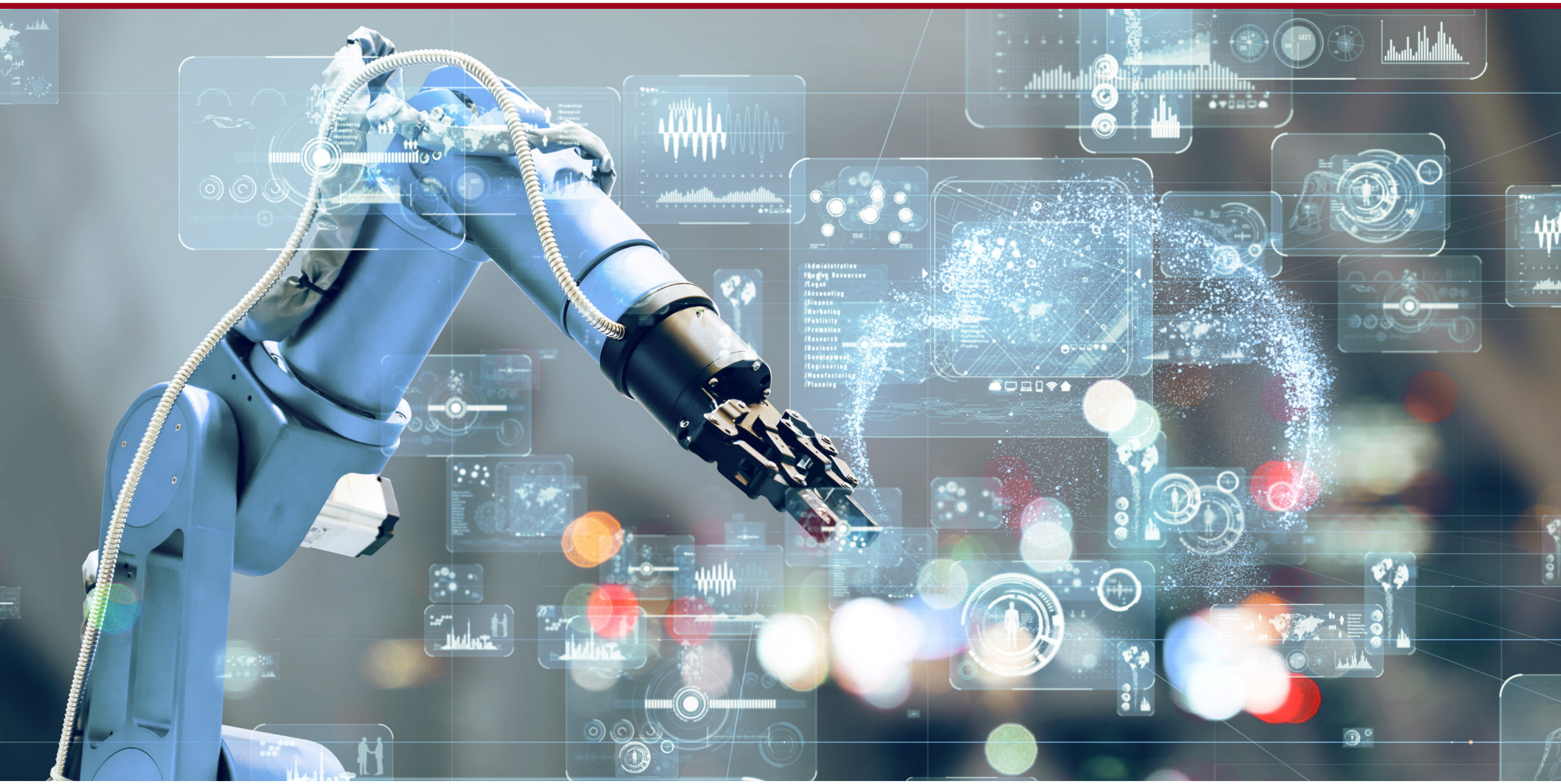
In order to realise their full potential, the overall approach to their internal connections and connectivity to the wider network needs to be carefully considered during all phases of design and implementation.

06

New-generation 5G networks being rolled out in 2020 with high data speeds and low latency will make cloud robotics a reality. Future mobile, autonomous robot platforms will be powered by real-time processing performed in cloud-based servers.

07

Industrial networks and systems are at risk of security breaches, so the encryption of hardware, networks and the surrounding infrastructure is an essential part of the system design.



Overcoming the Financial Obstacles of Automation - How Affordable Robots Can Help Smaller Companies to Participate

Though, so far, it has generally been larger organizations that have implemented automation, it should not be considered exclusive to them.

Small and medium-sized enterprises (SMEs) can equally gain from introducing automation in their factories and workshops. After all, industrial robots ensure greater productivity and eventually lead to higher profitability - and these are of importance to businesses of any size.

The problem is that most SMEs still find such robots prohibitively expensive to buy. Additionally, setting up, programming and maintaining conventional robots involves a significant learning curve, and this results in yet more expense. Even if they overshoot their budgets to purchase a complex industrial robotic arm, most firms end up only using a fraction of its actual features. Consequently, smaller companies will generally still be over-reliant on human labor, despite the proven advantages of using intelligent robotic machinery.

AFFORDABLE ROBOTS FOR All

Though SMEs have, until now, been overlooked by robotics manufacturers, this is starting to change. Fortunately, some have started to see how big a prospect the SME sector could be - and are coming up with innovative technologies to bring down the price tag of industrial robots. One such robotics start-up is Automata. This UK-based company has developed the EVA robotic arm, which is now seeing widespread commercial uptake. Before looking at this and other options that are currently available in greater detail, let's first define what the requirements of SMEs will be.

TECHNICAL CONSIDERATIONS FOR ECONOMICAL ROBOTICS

The core aspects that need addressing if a robot arm is to be effective in an SME context are as follows:

- **Compact Design:** Small companies usually do not have large workspaces or shop floors. With space at a premium, their robots should be optimally designed to take up only minimal footprint.
- **Energy Efficiency:** SMEs should factor in the power consumption of their robotic platforms, as this could otherwise prove to be a heavy operational expense. Smaller robots generally consume less power and will result in a lower total cost of ownership (TCO) over time.
- **Safety:** Conventional industrial robots, with powerful arms, can put workers at risk if precautionary measures are not followed. However, smaller, affordable robots are designed with a wider array of safety features incorporated - as they will need to collaborate with humans in close contact.
- **The Learning Aspect:** A lengthy training path for employees can offset any cost advantages of an affordable robot. Businesses should therefore consider choosing a simple-to-operate platform.

Automata's EVA low-cost robotic arm for industrial usage

EVA is compatible with smart cameras, PLCs and widely-used software packages - making it extremely versatile.

- **Maintenance:** Preventive maintenance, replacement of items prone to wear-and-tear, as well as batteries and refurbishment, should not be overlooked. These must also be added to the TCO relating to the selected industrial robot model.
- **Compatibility:** SMEs must make sure that their affordable robot can be used across a large number of processes. Again, an ideal robotic arm should be compatible with various software or hardware tools to make it versatile enough to attend to multiple tasks. This will make it easier to get a return on the investment made.

ABOUT EVA

Automata's EVA is a flexible, 6-axis industrial robot that is straightforward to integrate into various laboratory and workshop environments. This is allowing such operations to enhance their workflows, without requiring heavy financial outlay. As well as EVA being affordably priced, it is simple for staff to work with, so only minimal training is required.

This robot arm weighs less than 10kg and can move a payload of up to 1.25kg. It has a reach of 600mm. EVA is also AI capable, which makes it suitable not just for performing routine tasks (like pick-and-place of component parts), but also for critical jobs, such as quality control and sorting. It has been deployed for screening in several drug discovery labs and nucleic acid testing within diagnostics labs.

ST Robotics is another company that manufactures low-cost robots, especially collaborative industrial robot arms. NASA, IBM and Boeing are among its clients. Its R17 is a 5 or optionally 6-axis articulated robot arm. With its long reach, this arm is intended for operations that involve difficult access (such as testing, spraying and welding). The R17 comes in higher speed and heavier payload versions. It has a plug-and-play set-up with the controller, cables and project management software all part of the package.

FUTURE OF AUTOMATION AND AFFORDABLE ROBOTS

The post-pandemic world and growing adoption of Industry 4.0 (or even Industry 5.0) are expected to drive further demand for industrial robots. SMEs looking to remain innovative and differentiate themselves from their competition will certainly need robots in their production facilities and research labs.

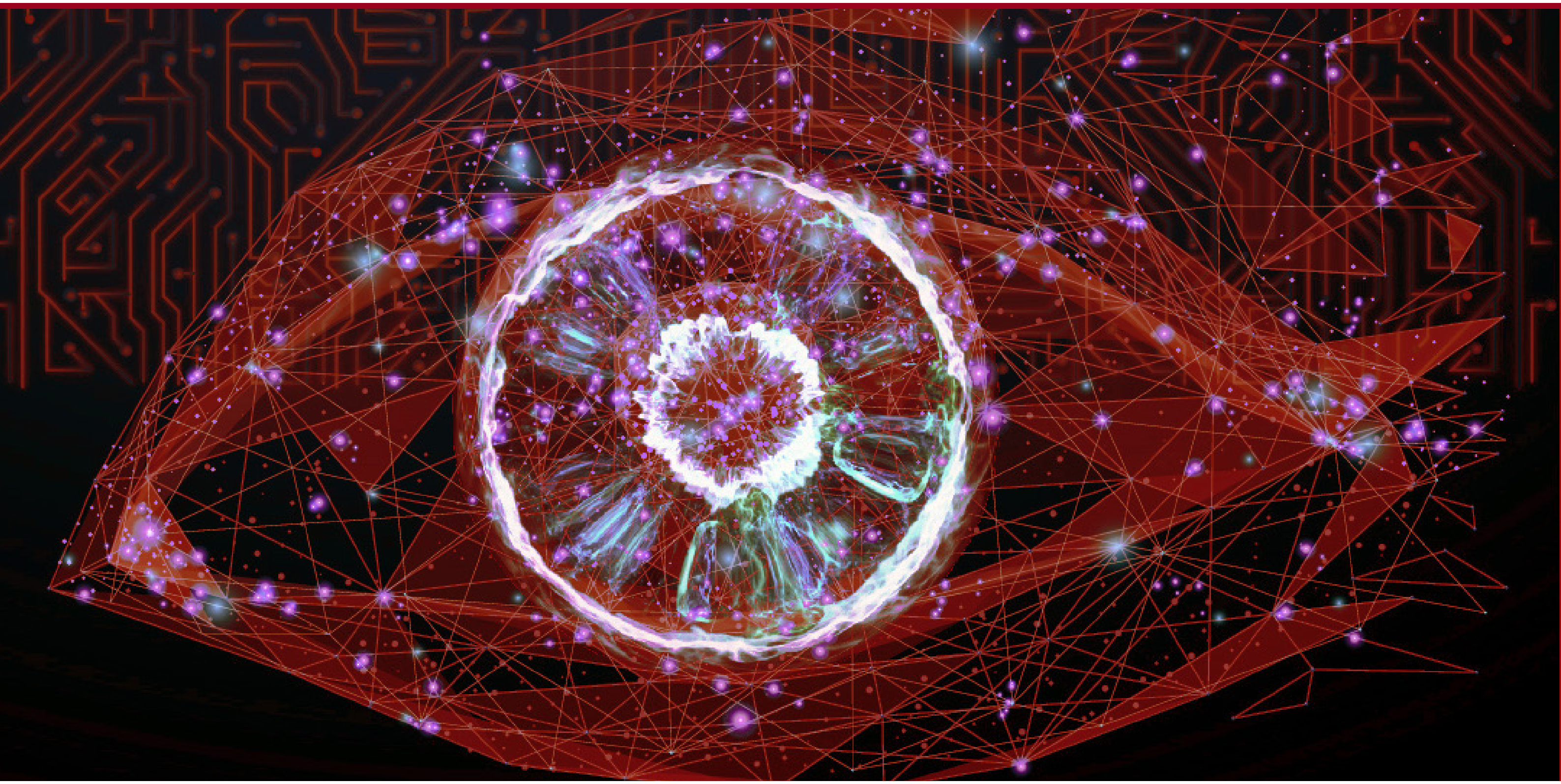
With more computing power and the ever-decreasing size of electronics hardware, the barriers to entry in relation to robots will subside. Consequently, affordable robotic solutions are destined to become increasingly accessible to companies - no matter what their size, and regardless of their budget constraints.

Of course, there are costs beyond just buying the robot itself, and SMEs need to be fully aware of these. If this is done correctly, however, then the numerous benefits of robotic automation can be realized and the investment fully justified.

PRODUCT OPTIONS

In addition to offering EVA robot arms, Distrelec has a wide variety of other robotic solutions in its portfolio - and these can help customers to attain their automation objectives.

Among the highlights here are the uArm Swift Pro robotic arm, which offers an entry-level DIY solution based on open source Arduino technology. Programming is simple, and can be done via Python. This robot arm is highly suited to hobbyists, as well as being of use in the educational domain. There is also the KSR10 robotic arm kit from Velleman, which is intended for integration into maker projects or potentially for the prototyping of larger scale systems.



Seeing, Hearing, Touching, Moving

Sensing the Real World.

Today's robots are becoming more human-like, not only in terms of movement but also in how they sense the real world. The rapid evolution of sensor technologies for robotic applications is supporting this trend, and the ability of robots to make decisions based on sensory feedback will have massive industrial and societal impact.

A wide variety of sensors are needed to give a robot a complete picture of the environment in which it operates. So, what are the key technologies that help robots see, hear, touch and move, and how are they developing?

EVOLUTION OF SENSING TECHNOLOGIES

The first mobile robot capable of any level of reasoning about its surroundings was built in 1970 by the Stanford Research Institute (now SRI International) in California. The robot, named 'Shakey', combined multiple sensor inputs, including TV cameras, laser range-finders and 'bump' sensors to navigate.

In 1972, Waseda University in Japan created WABOT-1, the world's first full-scale humanoid robot, which could grip and transport objects with its hands using tactile sensors. A vision system was deployed to measure distances, while directions to objects were gauged using external receptors – artificial eyes and ears.

Just two years later, David Silver designed the Silver Arm, which was capable of fine movements that replicated human hands with feedback provided by touch and pressure sensors.

There have been many more notable advances since these early robot sensing efforts. Arguably the most famous was ASIMO, which was created out of Honda's humanoid project in 2000. ASIMO could communicate with humans, and recognise faces, environments, voices and postures.

Ongoing research into sensor capabilities has resulted in greater adoption in the industrial robot sector. And, as with all technologies that make the leap from research lab to commercial production, cost is falling in line with uptake. Thanks to the proliferation of industrial robots volumes will rise and costs will fall further, making the latest sensor technology available to all, not just multinational robot OEMs.

SOUND AND VISION

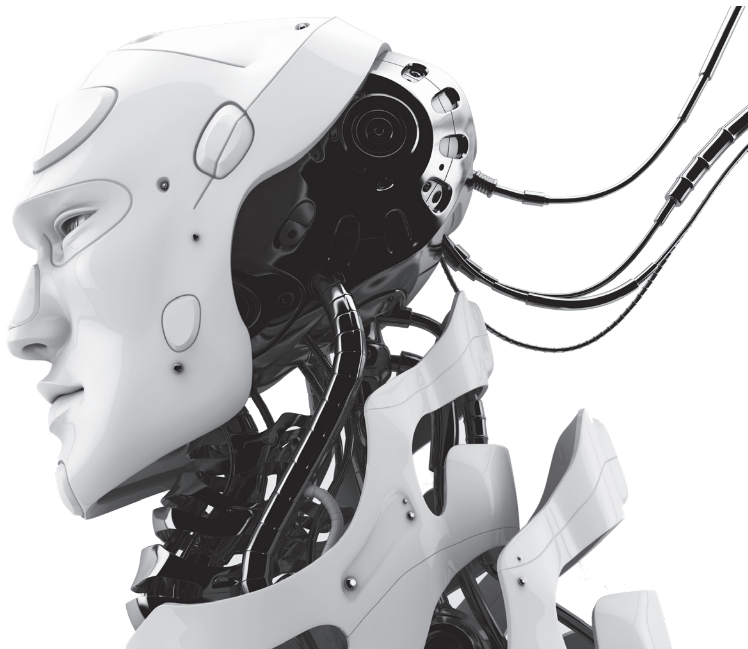
Fundamental to primary robot intelligence, vision sensing can be based on technologies ranging from the traditional camera, sonar and laser, through to the latest RFID technology.

Light detection and ranging (LIDAR) systems are also a popular choice for robot vision. This technology bounces light off nearby surfaces to create a 3D map of the world around it. LIDAR is like radar in its basic mechanics, but because it uses light, not radio waves, it offers greater resolution.

There are many key advances in vision-related hardware, not least the development of high-speed, low-noise CMOS image sensors, and new 2D and 3D vision systems.

2D vision is essentially a video camera that can perform tasks ranging from the detection of motion to locating parts on a conveyor, thereby helping the robot coordinate its position. 3D vision systems normally rely on either two cameras set at different angles, or laser scanners. With this technology, a robot can detect parts in a tote bin, for example, recreate a part in 3D, analyse it and pick the best handling method.

Complementing vision sensors, audio sensors based on multiple microphones can be deployed to determine the direction and intensity of a person's voice, or listen to sound-based commands. Sensitivity can be adjusted using a potentiometer. Microphone technology has been around for a long time, but in the future, sound/audio sensors may be able to determine the emotional status of a human voice. However, this will demand analogue-to-digital conversion (ADC) and digital-signal processing (DSP) electronics in tandem with a powerful microprocessor and advanced software.



TOUCH

A sensing device that specifies contact between an object and sensor is a tactile sensor. These are found in everyday objects such as lamps that brighten or dim by touching the base, for example. The stimulus-to-response pathways witnessed in electronic touch-sensor operations replicate human processes that involve the skin, signal transmission via the nervous system, and brain.

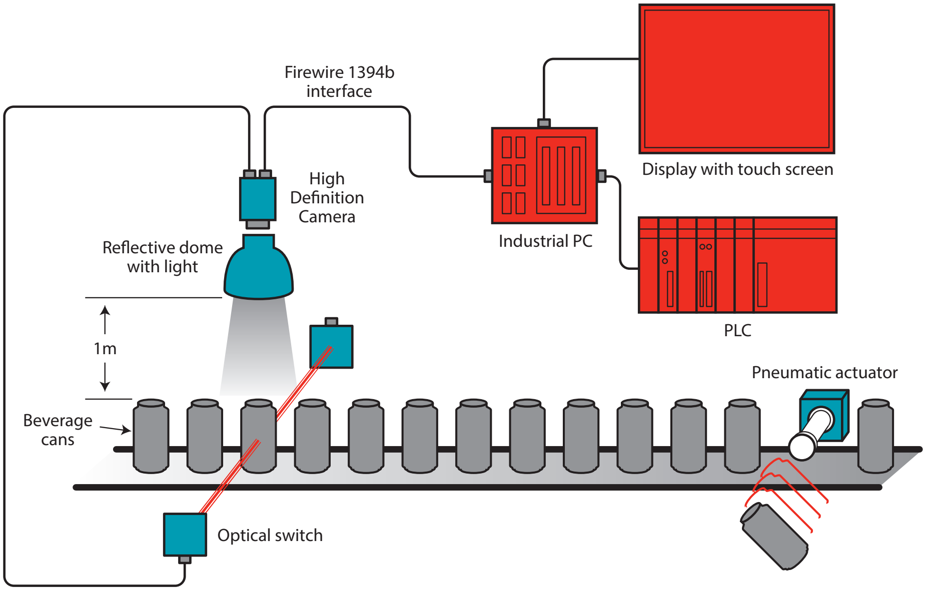
Touch-sensor options include wire resistive – which measure the resistance between electrically resistive layers at the point of contact to determine the touch position, surface capacitive, projected capacitive, surface acoustic wave and infrared. Among recent advances in this area are adaptive filters. Applied to robot logic, such filters enable the robot to predict the resulting sensor signals of its internal motions, screening out any false signals. As a result, contact detection is improved and false interpretation reduced.

FORCE/TORQUE

As vision gives eyes to a robot, force-torque (FT) sensors give 'feel', enabling users to know the force a robot applies with its end effector. This can aid assembly operations – if a component does not fit well, for example, feedback from the sensor allows the robot to adjust its movement and re-orientate the part in the correct position.

An FT sensor detects different forces and torque levels in up to three geometric (XYZ) axes. Typically, the sensors are fitted at the robot flange or wrist so that effort can be measured effectively. Selection criteria for FT sensors include the number of measured axes, physical dimensions, force range and communication rate.

FT sensors are important in collaborative and safety-based functions, as force-limiting capability is essential to robotic systems that can work safely alongside humans.



Cameras can be used to recognize the location and orientation of objects on a conveyor belt

PROXIMITY/COLLISION DETECTION

Proximity sensors that detect the presence of nearby objects (or targets) without any physical contact are placed on moving robot parts such as end effectors, with the sensor emerging from sleep mode at a pre-specified distance. Working on the principle that 'no contact is better than some contact', one of the growth applications for proximity sensors is in collaborative robots, where they help to ensure a safe environment for human workers.

Different targets demand different sensors – a capacitive or photo-electric sensor, for example, may be appropriate for a plastic target, while inductive proximity sensors always require a metal target.

Sometimes user-adjustable, the maximum distance that a proximity sensor can detect targets is defined as its nominal range.

Proximity sensors typically offer high reliability and long functional life thanks to the absence of moving parts and the lack of physical contact between sensor and target. The wide variety of types includes those based on capacitive, eddy-current, inductive, magnetic, optical, photo-resistive, radar, sonar, ultrasonic and fibre-optic technologies.

Infrared sensors, for instance, transmit a beam of light that is reflected off a target and captured by a receiver, while ultrasonic sensors generate high-frequency sound waves whereby the presence of an echo suggests interruption by an object.

Using ultrasound rather than infrared solves the challenge of the short range, as well as the need for calibration. Ultrasound is reliable in any lighting conditions, and is fast enough to take care of collision avoidance for a robot. It can also handle being shaken, as long as the motion is not exceptionally fast.

POSITION

Used for sensing and controlling arm position, the three most common types of position sensors are encoders, potentiometers and resolvers.

Popular types of encoders – which are used for converting angular or linear displacement into digital signals – include linear, rotary, incremental and absolute.

Incremental encoders have a glass disc with discontinuous stripes. A phototransmitter is present on one surface of the disk and a photoreceiver on the other. When the disk commences rotation, the light beams are finished alternately and interrupted, delivering output as a pulse train whose frequency is proportional to the disk rpm. Used mostly to determine the absolute position of a part, absolute encoders are similar to incremental encoders, with the stripes set to give a binary number that is relative to the shaft angle.

Potentiometers, which can also be used to determine position, are essentially 'voltage divider' systems that produce an output voltage proportional to the position of a rotating wiper in contact with a resistive element. The wiper separates the voltage of the resistive element into two parts and, by measuring voltage, its position can be pinpointed.

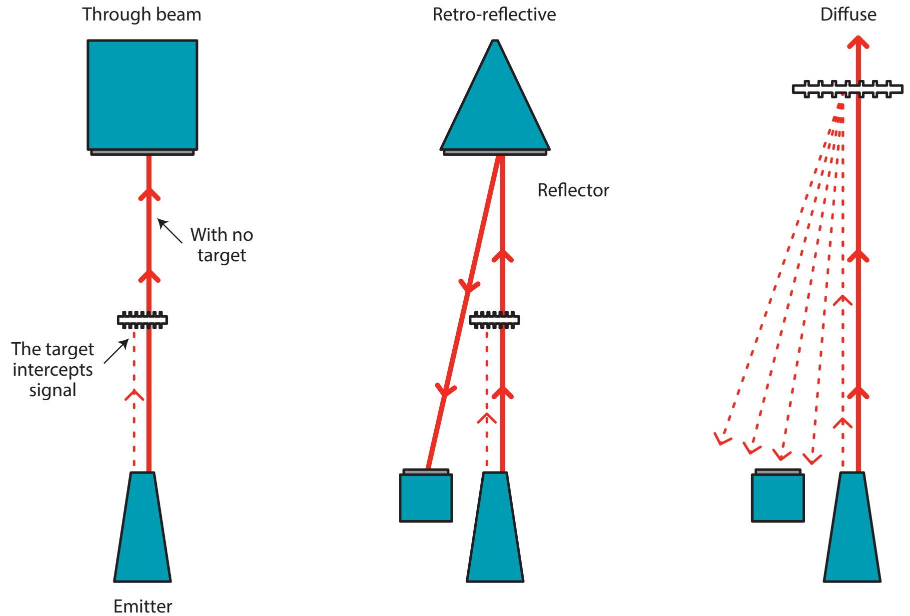
Like a potentiometer, resolvers are analogue devices. In this case, rotary electrical transformers are used for calculating degrees of rotation. An AC signal is needed and the output signal of a resolver is proportional to the angle of rotating element with respect to the fixed element.

FURTHER ADVANCES

Robot sensing technology is advancing rapidly, offering up a myriad of advanced and sometimes radical industry solutions for safety, and supporting more effective forms of collaboration between people and machines.

Existing sensors, including cameras and depth sensors, are often affected by lighting and offer only a rough idea of a person's position in 3D space. Emerging safety systems allow people to work in closer proximity to powerful robots, which will shut down completely if a person moves too close. By tracking a person's motions more precisely (for instance using enhanced radar techniques), next-generation systems will make it possible for powerful robots to work in concert with a human co-worker. Such technology might also improve efficiency, because workers could grasp something that a robot has finished working on, without fear of being injured.

Another recent breakthrough is a flexible sensor 'skin' that can be stretched over any part of a robot's body to accurately convey the information about shear forces and vibration that is critical to grasping and manipulating objects. The skin mimics the way a human finger experiences tension and compression as it slides along a surface or distinguishes between textures. This tactile information is measured with similar precision and sensitivity as human skin, and could vastly improve robots' ability to perform all tasks, from industrial to medical procedures.



Sensors can receive signals directly or by reflection until broken by an object; diffused signals are reflected back by the object

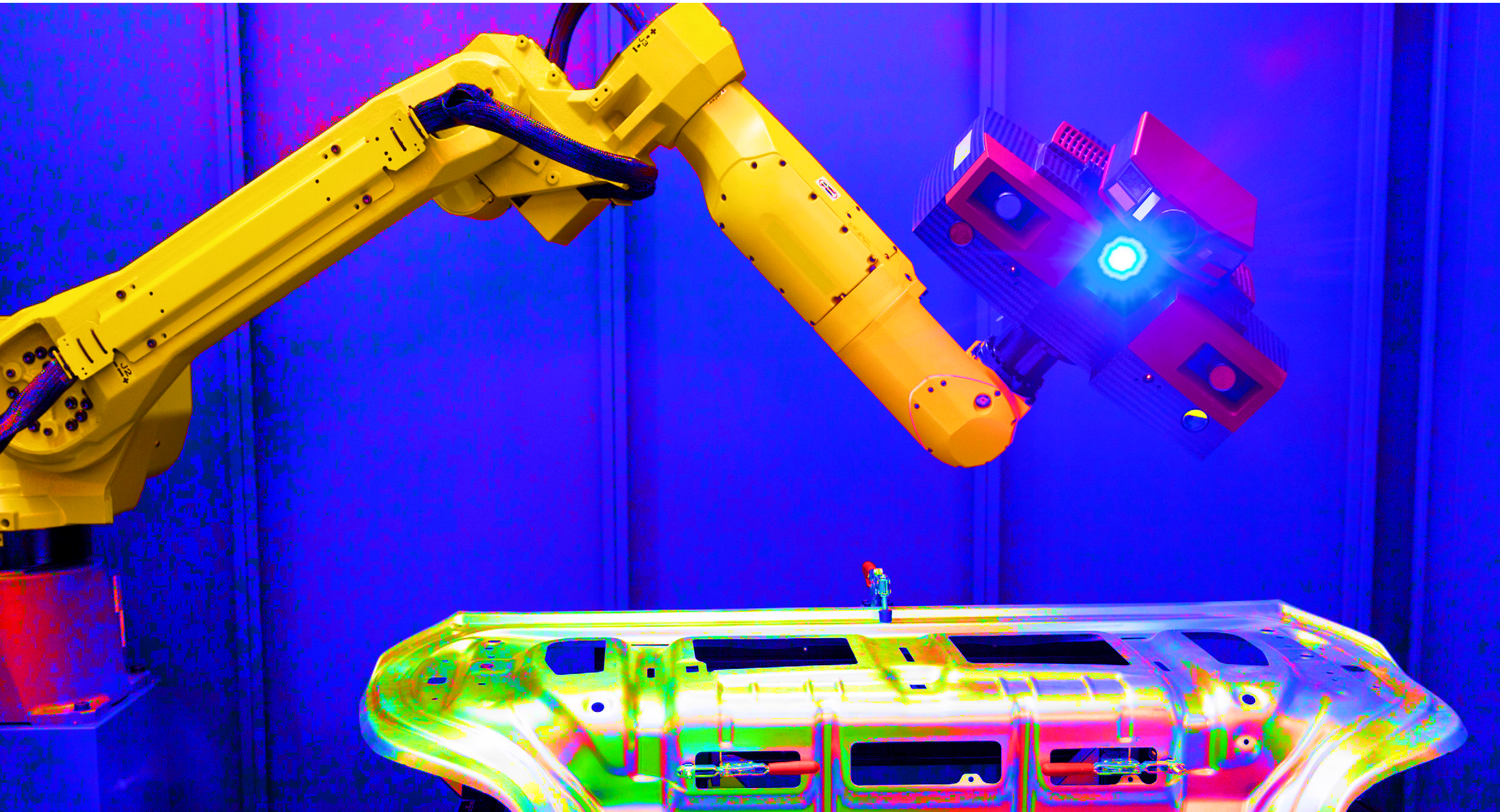
ROBOTICS SENSOR MARKET

The increased use of robots in industries such as automotive, food and beverage, renewable energies, logistics, medical care, and telecommunications is a major factor that is expected to augment growth in the industrial robot sensors market over the coming years.

GM Insights expects that the robot sensor market will be subject to an 11.5% CAGR between now and 2028 - with more than 12 thousand units being shipped over that time.

iDTechEx forecasts that vision systems alone will command a worldwide market value of $5.7 billion by 2027, while force sensing technologies will reach $6.9 billion by that stage.

A Technavio study predicts that the materials-handling segment will dominate the industrial robot sensors market over the next decade - particularly in sectors like automotive, food and beverage, packaging and pharmaceutical. Furthermore, increasing momentum behind Industry 4.0/5.0 will also prove a significant factor, driving market growth in the coming years.



DISTRELEC

KEY FACTORS TO CONSIDER

01

Match sensors to capability. If desired, all human senses can be replicated using the latest sensor technology, though not all will be necessary in the majority of industrial applications.

02

For vision, will camera technology be sufficient for the application? If so, will 2D or 3D vision be needed? Or should further options including LIDAR, sonar, radar and RFID be investigated?

03

How many audio sensors, if any, are likely to be required, and where will be the best positions?

04

The uptake of touch/tactile sensor technology has grown enormously in the past decade, and growing numbers of industrial robots are taking advantage. Choose between touch sensor types such as wire resistive, surface capacitive, projected capacitive, surface acoustic wave and infrared.

05

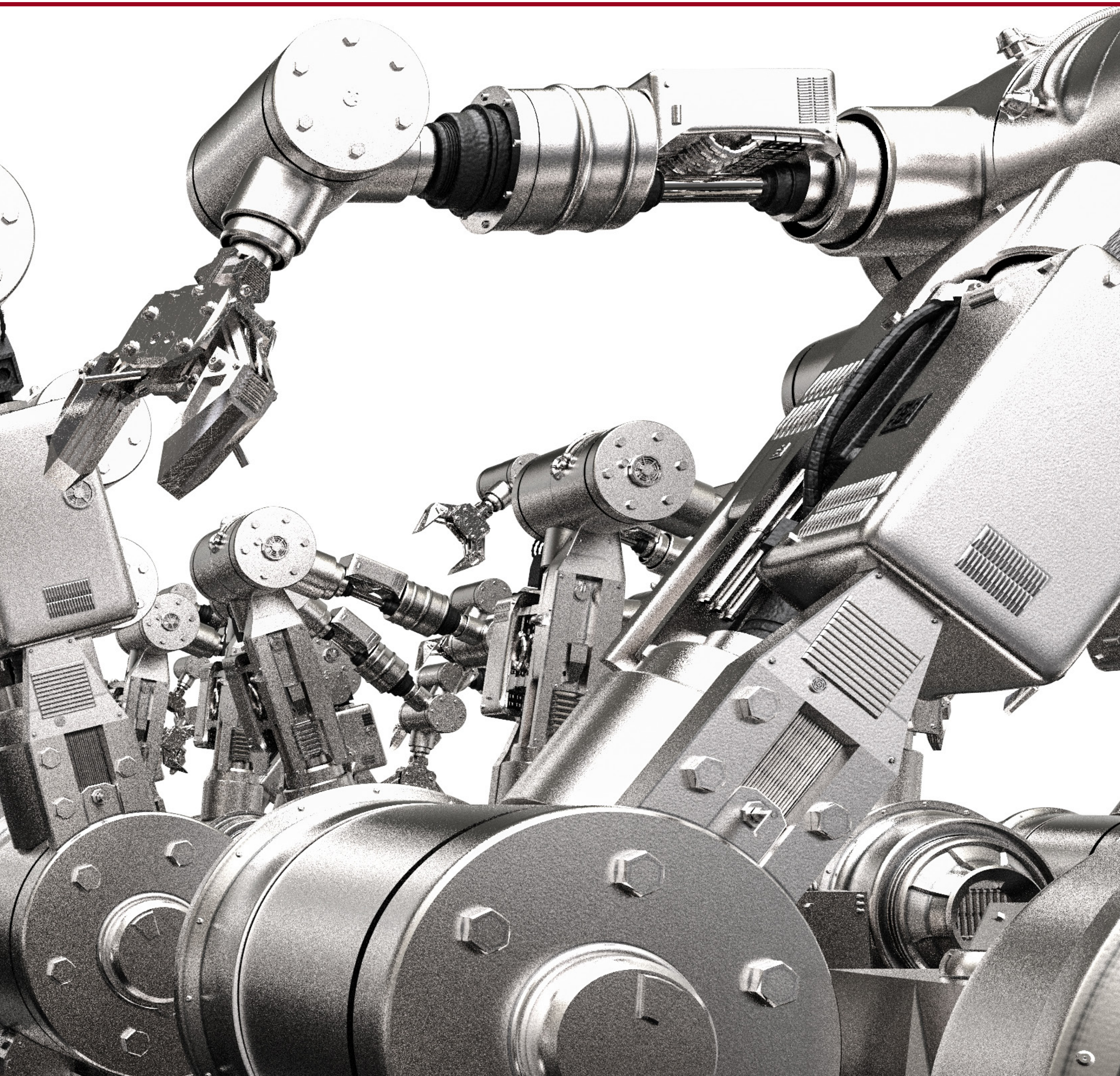
When choosing force-torque sensors to detect the different forces and torque levels applied on the robot wrist or tool, consider the number of measured axes needed, force range, communication rate and physical dimensions.

06

Proximity sensors also have many uses in robotics, particularly with the rapid emergence of collaborative models. When it comes to selection, identifying target material, nominal range and lighting conditions may all be important.

07

Options for position sensors are typically limited to encoders, potentiometers and resolvers, and understanding of whether relative or absolute position is needed will be key.



Our thanks go out to…

FOR HELPING WITH THE CREATION OF A GUIDE TO **ROBOTICS AND AUTOMATION**, WE EXTEND OUR **THANKS** TO THE FOLLOWING PEOPLE AND ORGANIZATIONS:

Matthias Heutger – Deutsche Post DHL Group

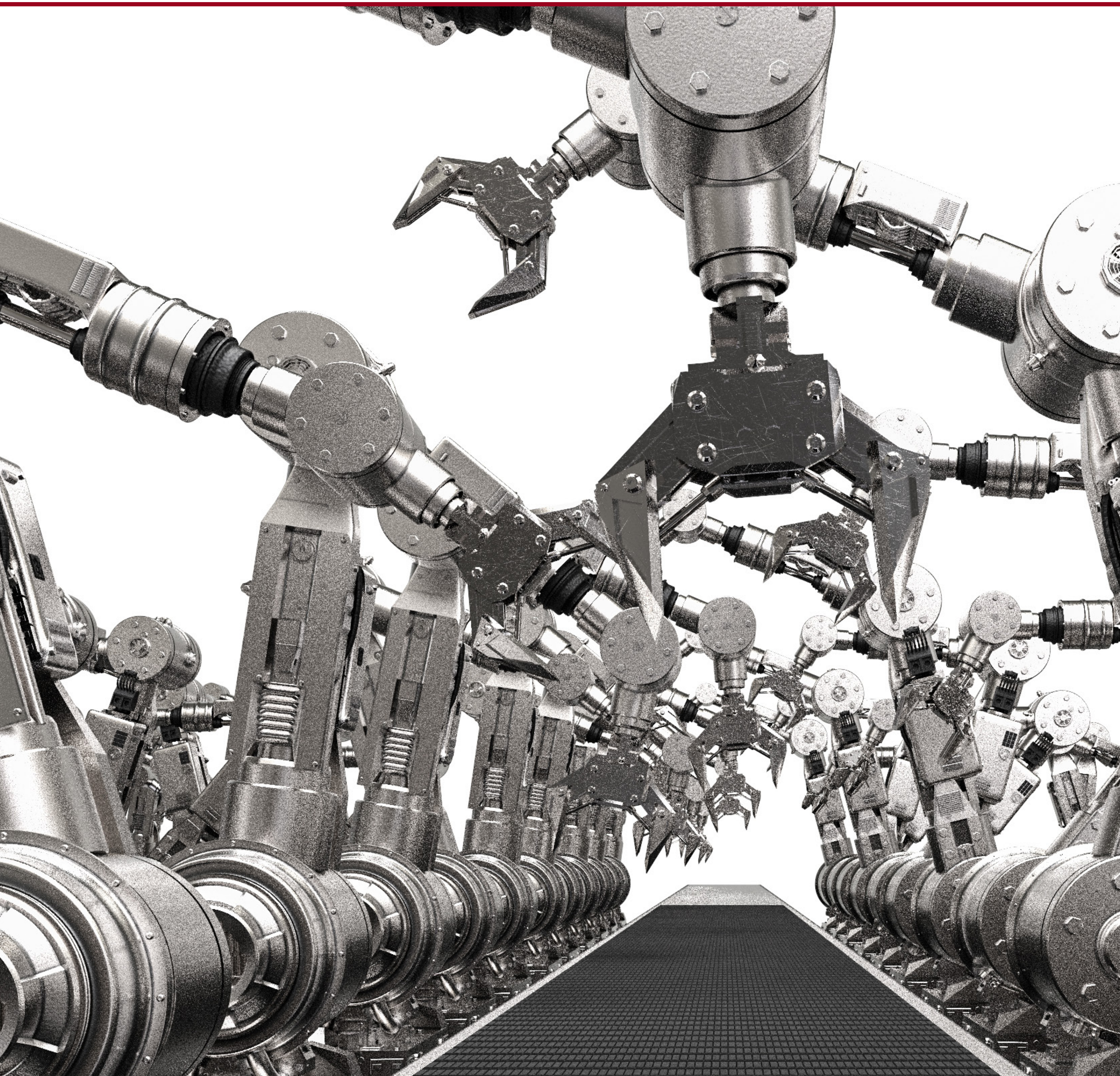
The Media Relations team at Trumpf GmbH

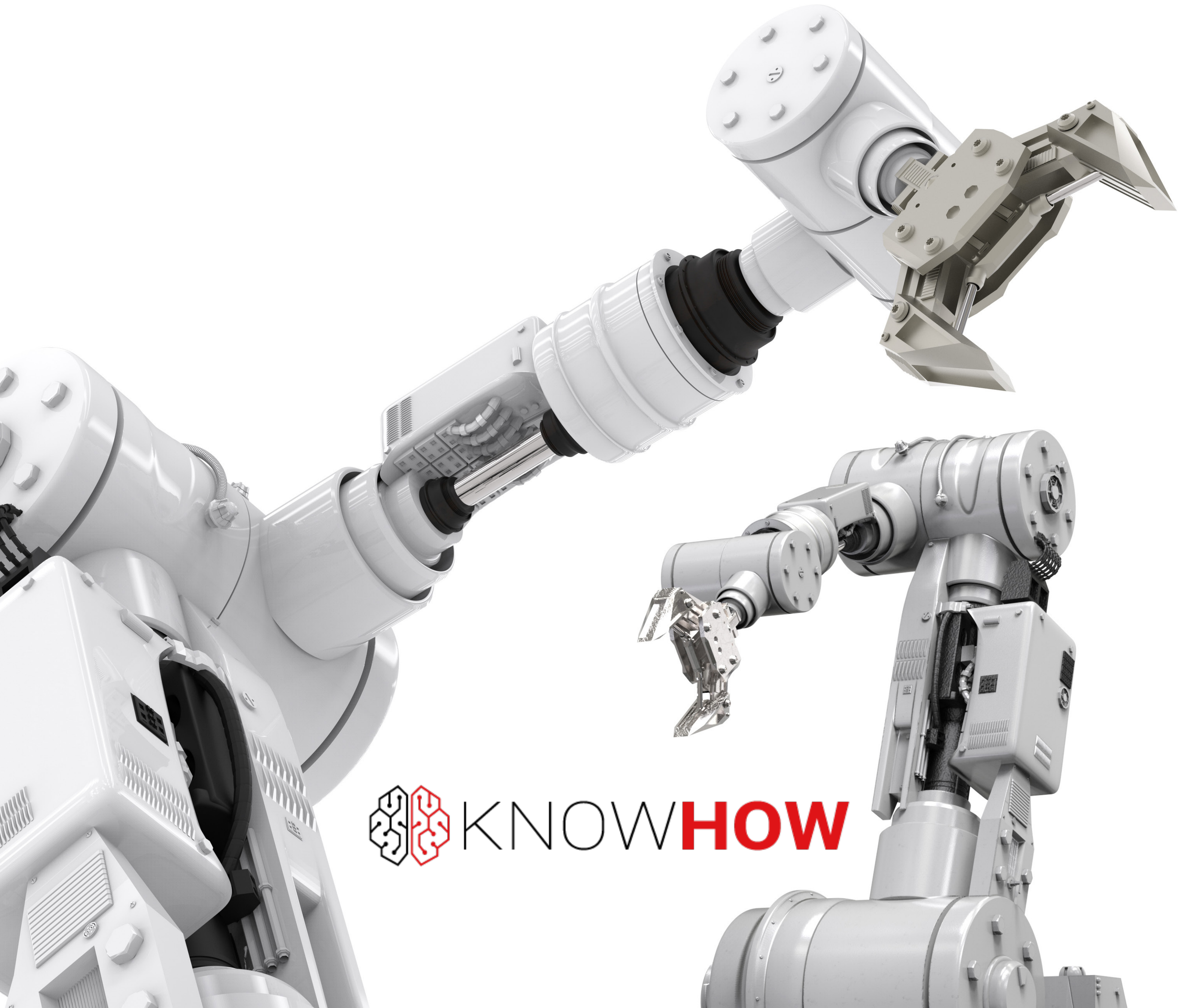
The Technology PR and Communications team at Ocado Technology

The Marketing Team at Medineering GmbH

Publitek

The Marketing Team at Distrelec

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