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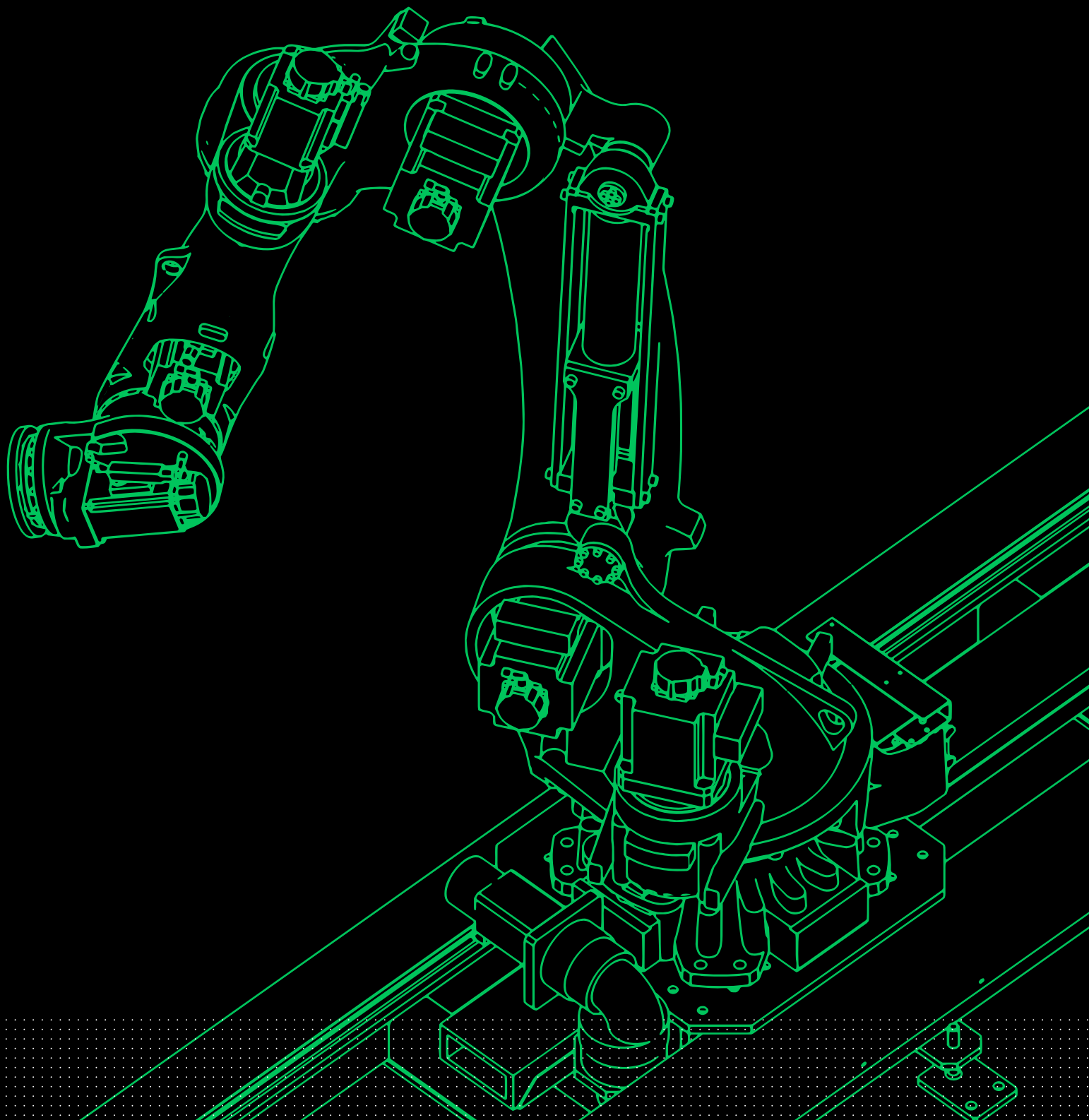
HOW TO DESIGN A COBOT

Exploring cobots, AI and machine vision to close the productivity gap faced by SMEs in the global industrial sector



EXECUTIVE SUMMARY

There is a productivity gap between small and large manufacturers and this gap is attributed to a limited adoption of automation.

It may feel like robots and artificial intelligence are everywhere and in some environments this is true. But the heavy use of new technologies is mainly restricted to larger OEMs, while SMEs exhibit limited amounts of adoption.

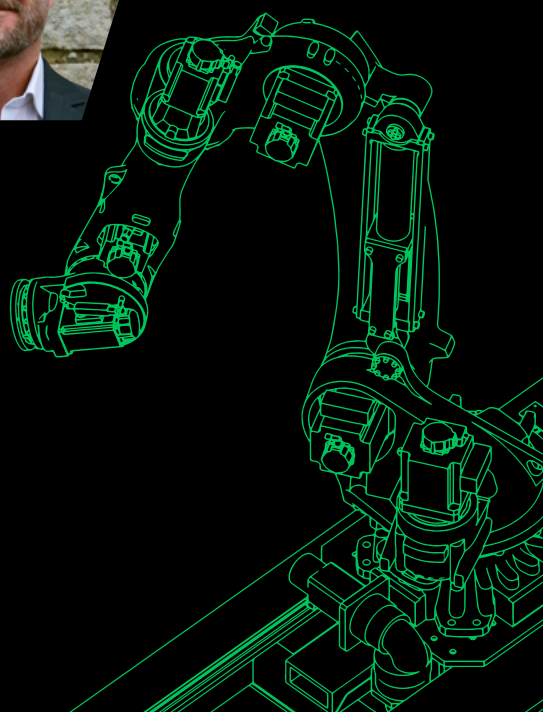
Cost is often cited as the main reason. However, studies indicate that the capital investment needed to automate can be recovered quickly. This doesn't remove the difficulty SMEs may face when finding the investment and skills needed to make that change.

The development and continued expansion in lower cost automation could remove the financial barrier to adoption. Robotics is one area where costs continue to be eroded, while technologies like machine vision and AI continue to advance.

Collaborative robots are a good example of this. More manufacturers, both traditional robotics companies and newcomers to the industry, are investing in the development and manufacture of collaborative robots.

This whitepaper provides insights from leading manufacturers to explain where the technology is today and where it is going in the future.

Philip Ling, Senior Technology Writer, Avnet



Introduction

Collaborative robots, or cobots, are redefining what we mean by factory automation. Industrial robots are large, purpose-built machines configured for specific tasks. Cobots are smaller, easily repurposed and more flexible.

The automated industrial robot operates separately from humans in both time and space. Robots will not function if an operator is detected in the same area. It means a human cannot work in the same space as a robot, at the same time.

Cobots are changing this dynamic. Instead of being isolated from an operator, they are designed to work alongside them. Cobots can assist a human operator or another machine. They are much closer to being a true replacement for the human in the loop.

Designing any machine to be used in multiple ways presents challenges. The reason industrial robots are so efficient is because they focus on repeating a single task continuously. A cobot also operates repetitively but they are intended to be more readily adapted to a different task.

Mark Gray, Universal Robots

Where is the line between robot and cobot?

We spoke with Mark Gray, the UK and Ireland manager for Universal Robots. The company recently reached a milestone, passing 75,000 cobots installed worldwide. Gray explained where cobots fit in the market.

"It's a different aspect of automation, as opposed to the normal industrial robot. Collaborative robots can be used in lots of different aspects of manufacturing, for pick and place, packaging, screwdriving, soldering, and mounting components."

Key features of cobots include their speed of deployment and simple learning curve. Manufacturers can get set up fast and see the benefits quickly.

"We've simplified the software so that end users can program it," Gray said. "That opens the possibility to automate processes that before would have been really expensive and take a long time to automate. It's giving that flexible automation back to the end user and manufacturer."

> "We've simplified the software so that end users can program it."

SUGGESTED FURTHER READING

Factory automation realizes boost from new technologies

Industrial automation is enabled by robust and proven technologies. It adapts slowly to change but makes good use of the technologies it adopts. Take a look at the technologies being adopted now, and those coming soon.

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Stuart Cheyne is the general manager for Kawasaki Robotics in the UK. He explained that Kawasaki Robotics has been making robots for around 50 years and was the first company to bring an industrial robot to market in Japan.

Cheyne also outlined the company's plans to bring a new cobot to market that will have a payload of 3, 5, 8 or 10 kg and a repeatability of 0.02 mm.

"The whole idea of a cobot is that it can be used in close vicinity to a human being. In its standard format an industrial robot doesn't have collision detection. What we're seeing with cobots is that it is a really good introduction for people who haven't thought about robotics until now."

Stuart Cheyne, Kawasaki Robotics

"The whole idea of a cobot is that it can be used in close vicinity to a human being."

Jan Hennecke, Igus

Cobots are breaking down barriers

Jan Hennecke works for Igus, a company that develops high-performance polymer technologies for automation applications. Hennecke is also product manager for the company's cobot, ReBeL, and the RBTX marketplace. RBTX is the part of Igus that focuses on low-cost robotics. The ReBeL cobot is part of the product portfolio.

Hennecke explained that the two main barriers to using cobots in automation are cost and complexity. The ReBeL cobot is a flexible platform with an emphasis on low cost, that has been designed to be customized. Customers can download a software application to start developing an application before placing an order.

Unlike most cobots, the ReBeL cobot is offered either with or without the controller circuitry. Choosing the option without controller lowers the cost further. The mechanical design of ReBeL is also configurable, based on the application.

Igus makes use of software for the pre-configuration stage. Using digital twins to configure a cobot for an application is becoming more common among cobot manufacturers. A digital twin helps with the specification at the exploratory stage and with ongoing operations after deployment.

ReBeL, Igus cobot in the lab

Inovo Robotics is a start-up with a unique offering. It has developed the industry's first and currently only modular cobot. Rather than customers specifying the cobot at a low level, Inovo's robot has been designed with interchangeable parts. This makes it reconfigurable even after it has been specified.

Jonathon Cheung, co-founder of Inovo Robotics and a mechanical engineer, explained how its robots are built with 12 degrees of freedom and typically six moving joints. To have this level of flexibility in a mechanical system requires an equally flexible control system.

"We have a very high level of understanding and precision to make a system flexible and highly accurate for a configuration that could be as long as 1.3 meters or as short as 700 mm," said Cheung.

Jonathon Cheung, Inovo Robotics

> "We have a very high level of understanding and precision to make a system flexible and highly accurate."

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How do you make a cobot inherently safe?

Cobots are designed to work collaboratively and closely with humans. With that in mind, take a look at one of the market's safest cobots.

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Programming a cobot

Cobot manufacturers are recognizing how important it is to make cobots accessible at both the hardware and software level. This is an area that separates cobots from industrial robots. The skillset needed to program an industrial robot introduces another barrier to adoption.

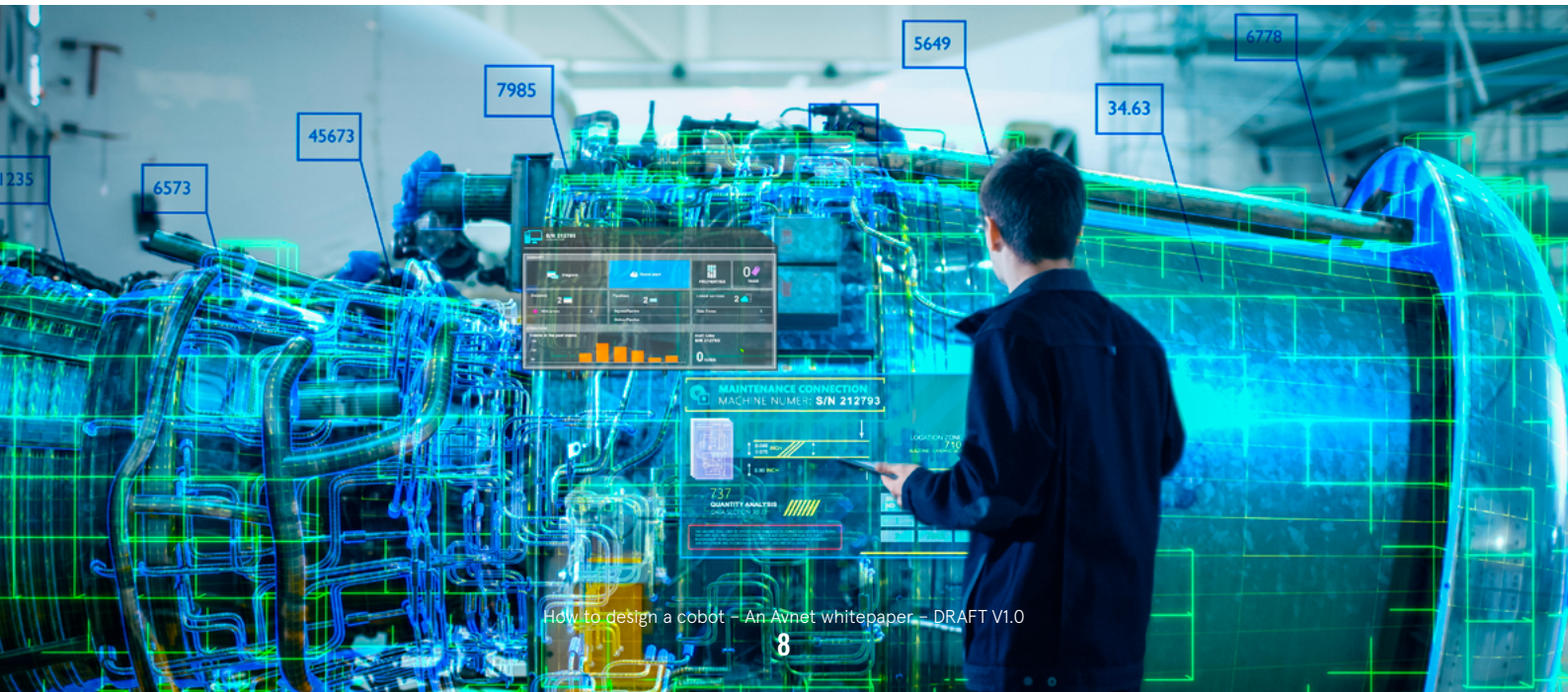
The cobot programming environment has, in general, been universally simplified. This is entirely intentional because it makes owning and operating a cobot much simpler. OEMs no longer need a dedicated technician to manage the robot.

In the case of Inovo, the programming language resembles the Scratch visual programming language, using a drag-and-drop approach to building a list of instructions. The inherent safety of cobots means the potential to program the cobot to behave dangerously is limited.

Inovo's digital twin environment is also highly responsive to the movement of the real cobot. This environment uses a 3D scan of the customer's workspace and puts the cobot directly into that space. The virtual workspace can then be manipulated and modified to help ensure the cobot fits in the most efficient way.

It is also usual for cobots to be programmed by simply moving the cobot to a position and recording that position. This is only possible due to the sensors used for motion and position detection.

Digital twin



What are the limitations of a cobot?

The flexibility offered by a cobot comes with safety-related limitations. The speed at which a cobot moves will be restricted and it will move far slower than an industrial robot that is caged.

"The maximum speed our cobots can travel is 1 meter per second," said Universal Robots' Mark Gray. "But as a rule of thumb, collaborative speed is 250 mm per second." This is to ensure the cobot isn't carrying enough energy to hurt someone if they should come into contact with a moving cobot part.

Sensors are used to detect increased torque, which would indicate an obstruction. If this happens the cobot is put into a safe mode. It will need to be restarted by an operator.

Cobots are typically made of lightweight alloys, to minimize the moving mass. They also feature a human-friendly design. "If you look at the form factor, it uses rounded off lightweight alloy and we have tried to eliminate pinch-points," Gray added.

Kawasaki Robotics' Stuart Cheyne made the same point about his company's cobot design. "A cobot's speed is reduced and so is its load capacity, because it has to be used in conjunction with a human."

The amount of torque a cobot can apply will also be limited, for the same reasons. These factors mean the lifting capacity of a cobot will be much lower than an industrial robot. Typically, the cobots now on the market will have a maximum payload of around 10 kg at the end effector. Many will have a much lower payload than this, which will determine how it can be useful in a manufacturing environment.

Cobots are designed to be ergonomically kind to humans. They have smooth surfaces and rounded edges. Despite this, they have the capacity to be dangerous. The end effector is interchangeable and can therefore hold objects that could harm a person.

Every application requires a risk assessment. If there is unacceptable risk associated with the application, the cobot may need to be caged or operate in an environment that restricts operators from entering. This can render the cobot uneconomical for the task.

SUGGESTED FURTHER READING

Common industrial motors and how to drive them

Torque, speed and efficiency are three metrics that need to balance when selecting an industrial motor. We take a look at the most commonly used motors, what applications they are best for and how to use them efficiently.

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Machine vision, AI and your cobot

Robots and their close cousins, cobots, are programmed to repeat defined steps. They typically do not need vision sensors to do these tasks. Instead, they rely on information coming from outside their system. Machine vision is developing alongside robotics and the way these two paradigms now work together is adding another dimension to the term "collaborative."

There are multiple sensors inside a cobot. Rotary encoders help the control system know where each moving part of the cobot is relative to other parts and its fixed position. Sensors are used to detect collisions, typically these would be current sensors on the supply lines to the motors. A spike in current would indicate an obstruction. Torque sensors are also used. When the torque level increases due to an obstruction, the robot's control system will recognize this as a fault condition and put the robot into a safe mode.

Sensors are not being used to detect the cobot's environment. A cobot is unlikely to feature any kind of active object detection and recognition, or proximity sensing. You aren't going to program a cobot to react to unexpected changes in its operating environment.

For this reason, cobots on the market today are unlikely to be using artificial intelligence to control their actions. While this may be the logical direction of travel, cobot manufacturers seem to feel the industry is several iterations away from reaching this scenario.

Machine vision, however, is actively integrating artificial intelligence, along with sophisticated 3D sensing. And vision systems are being actively integrated alongside robots, to work collaboratively.

In a conveyor belt application, a vision system will monitor the products on the belt and provide the robot or cobot with data that includes coordinates and orientation. Armed with this data, the robot can pick the object from the belt and place it somewhere else ready for the next process.

All the intelligence in this class of application resides in the machine vision system. The level of intelligence in machine vision systems is still developing. Today, the industry is moving towards 3D systems using laser triangulation or time-of-flight to create point clouds.

If the vision system decides the object on the conveyor is defective or otherwise non-viable it simply doesn't pass the information to the robot. The robot is unaware that there is an object on the conveyor belt and makes no move to pick it up.

A natural extension to this, and one that is likely to happen at some point, is to pass the data from these sensors to an AI system. Rather than a binary go/no-go decision, the AI could be trained to evaluate how defective a part is and decide if it can be salvaged for rework. In this case, the robot may be asked to move it to a different bin for further processing, rather than outright rejection.

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An interview with a robot pioneer

Find out what's happening in the area of additive manufacturing using robots in this exclusive interview with Chief Technology Officer Chris Elsworthy.

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The potential for collaborative robots

The market for collaborative robots is expected to grow at a compound annual rate of around 30% through to 2030. SMEs will drive that growth and benefit from the productivity gains.

Subsequent growth among SMEs will have an impact globally. Some of those companies may grow beyond their sector to become leading OEMs.

Demand will sustain growth, but the real test may be how quickly and how effectively cobot manufacturers and end users adopt other enabling technologies, such as artificial intelligence and high-speed connectivity.

Avnet continues to monitor the technology landscape and adapt its business to reflect the needs of its customers, suppliers and partners.

ABOUT AVNET

As a leading global technology distributor and solutions provider, Avnet has served customers' evolving needs for an entire century. We support customers at each stage of a product's lifecycle, from idea to design and from prototype to production. Our unique position at the center of the technology value chain enables us to accelerate the design and supply stages of product development so customers can realize revenue faster. Decade after decade, Avnet helps its customers and suppliers around the world realize the transformative possibilities of technology.

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