the o.i.

New ideas, new technologies, new production concepts

What will make us successful tomorrow?

Smartening up production – the potential of intelligent production

Automated assistants for optimal patient care

Logging in instead of calling someone? Digitized sales

Editorial

Dear Readers,

No topic is on our minds like the future. The need for forecasts is deeply embedded in our nature. Periodically, researchers and institutes attempt to point us in the right direction. There are studies on the future of work, life, production and industry. For businesses in particular, looking to the future is existential.

How will sales and customers communicate with one another? How will we live and shop? How can we ensure quality care in hospitals? How intelligent will robots be and what abilities can they possess? And of course: what does a company need to survive in the face of the constant new trends?

Our mission at KUKA is to create automation. Driven by our pioneering spirit, we give our customers a competitive edge. And in the new edition of our company magazine we address just this question: what will make us successful tomorrow?

There is no crystal ball. But we can prepare for an unknown future with innovations and the courage to forge new trails – and with the right ideas and technologies we can even shape this future ourselves.

In focus

Technology

Imagine

Connect

Digital business on the advance

Until now, online services have been important primarily in the end-user sector. However, digital channels are also playing an increasingly significant role for the distribution of complex products.

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New attributes for robots

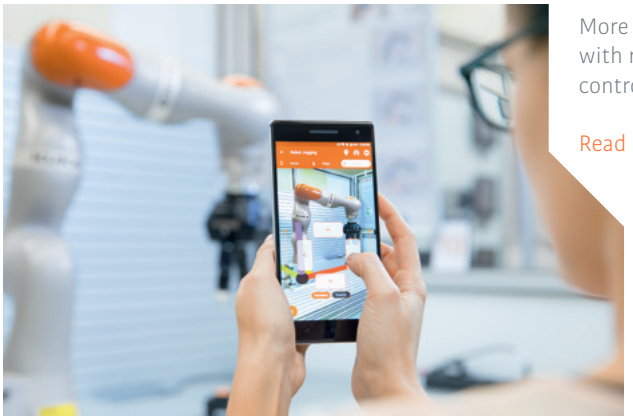
Perception, such as vision, is one of the most important human attributes – and one of the greatest challenges in robotics.

Read more on page 18

Easy to use

More and more people are working with robots – and simple operator control is a key to acceptance.

Read more on page 6



Technology

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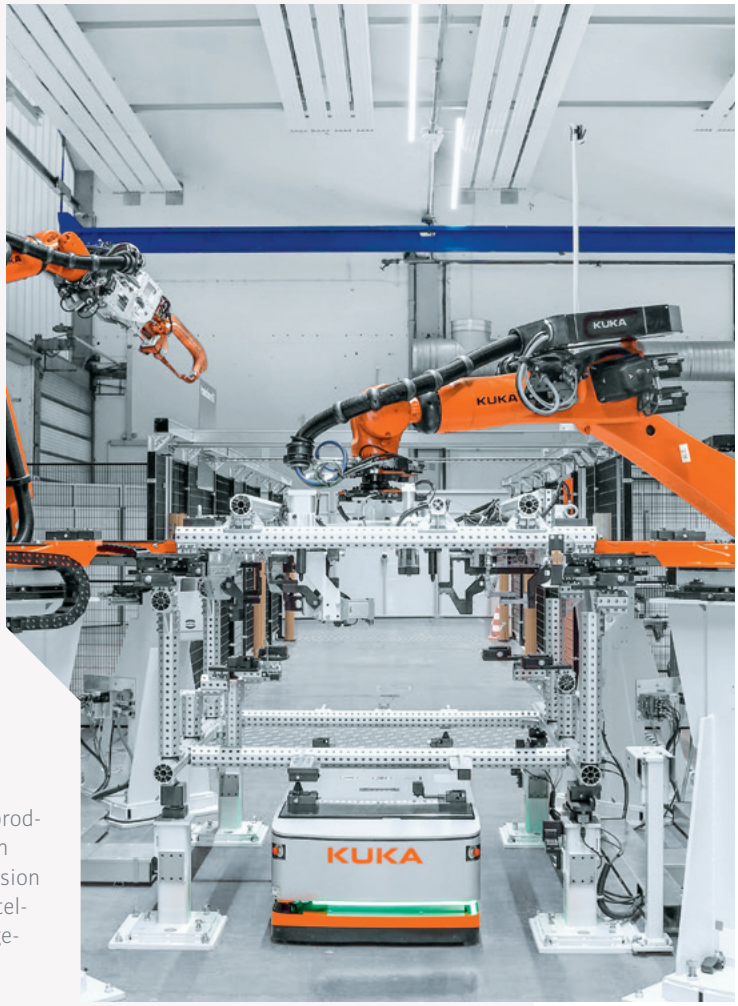
All about new technologies in industrial workshops and beyond.



Smartening up production

Production of as many different products as possible in a single system with the shortest possible conversion times. One solution: a neutral, intelligent system with diverse, changeable tools

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An important factor for the acceptance of robotics: simple, intuitive operator control

From smartphones to remote controls: we are used to controlling technical devices simply and intuitively in our everyday lives. This requirement is increasingly spilling over into industrial production. Until now, operator control of robots was the preserve of experts.

My robot: easy to use!

In the summer of 2018, German astronaut Alexander Gerst performed a number of successful robotic experiments on board of the International Space Station ISS, controlling a robot with a tablet. What made this special was that while Gerst was in orbit some 400 kilometers above the earth, the robot was located in the Mars laboratory of the German Aerospace Center in Oberpfaffenhofen near Munich. As the experiment shows, there are ever more potential applications for robots – and innovative means of controlling them.

Robots like the one used in the Mars laboratory are also increasingly to be found in industrial environments. They assist personnel in a wide range of different applications. It is hardly surprising that sales of industrial robots have been growing strongly for years, as the International Federation of Robotics IFR regularly assesses. Its figures for 2017 showed a new record for the global deployment of industrial robots with an average robot density of 85 units per 10,000 employees in manufacturing industries, up from 74 in 2016. Robots relieve humans of physically strenuous tasks and also help to absorb the negative effects of demographic change.

Acceptance due to simple operator control

Despite the advantages, however, only a minority of the production workforce operates the robots. “Until now, operator control of robots has required a great ability to think abstractly. The specifications regarding safety regulations are also high. For this reason, programming is still rarely simple or trivial,” explains KUKA robotics expert Volker Schmirgel.

Jonas Schmidtler, employee in the Department of Ergonomics at the Technical University of Munich, sees things similarly: “In practice, operator control is predominantly the domain of experts. This is progressively leading to a bottleneck in the

Operator control options

industrial environment and operation is currently shifting away from experts and towards everyday users." Schmidtler thus argues for a rethink in production design: "In the past, most things that could be automated were automated. Only rarely was consideration given to the needs of employees. Acceptance needs to be won back here."

One possible solution would be the creation of a complementary working environment for humans and robots in which each side enhances the other with its respective strengths. The technology must adapt to the human workers. Simplified robot operation plays a major role here. There are various possible approaches, as Schmidtler explains: "Current approaches range from programming robots by demonstration, in other words by means of direct manipulation, to graphical user interfaces on which employees can select from preprogrammed blocks without the need for advanced knowledge of robot programming."

Not only operator control simplified by new technologies
The key to broader use of industrial robots is greater acceptance. One important factor is simple operator control of the robots. There is great potential, for example, in speech and gesture recognition. Augmented reality opens up new possibilities that go beyond mere operator control of the robots. Until now, commissioning robot applications has, to a great extent, involved working with assumptions and values based on experience. For example, it is not possible during system planning to depict the forces generated. "With augmented reality, physical forces can be visualized. This opens up a whole new range of potential applications. Both experts and robotic novices then benefit from the operator control options," says Schmirgel.

New types of control will make robotics more accessible to a considerably larger target group in the coming years. In the future, this will make the mechanical assistants an option for everyone.

Operator control with augmented reality

The approach of augmented reality is to enrich the real world with digital content. For example, 3D objects, images or text can be projected onto the screen of special glasses. This makes it possible to simplify complex tasks or to retrieve additional information in real time.

Speech control

The key concept here is 'natural language processing'. This technology defines methods for machine processing of human language. The goal is direct language-based communication between humans and robots.

Operator control by demonstration

With the aid of force-torque sensors, the operator guides the robot along the desired paths by hand. The forces and torques exerted by his hand are saved together with the coordinates of the points addressed on the path.

Graphical user interfaces

Employees no longer need to master a robot language, but simply select preprogrammed, graphically modeled blocks.

Operator control via gestures

Gesture control of the robot is intuitive. Real-time 3D data acquisition is the key to accurate recognition of human gestures and motion patterns. Software translates the signals to the robot.

New ideas for new cars

Autonomous vehicles and alternative drive systems are among the most important future technologies. In order to gain broad acceptance, the cars of tomorrow will need one thing in particular: new ideas for the associated infrastructure.

How will we move about in the future? It is not just experts that are occupied by this question. Automotive manufacturers are showcasing their latest electric vehicles at the major car shows and the topic of autonomous driving is being discussed in the media on an almost daily basis. “Today, electromobility is an integral part of an increasing transformation in mobility worldwide,” writes the German National Platform for Electric Mobility in its progress report for 2018. “The foundations have been laid for electromobility to enter the mass market successfully.”

In order for e-mobility to gain broad acceptance, however, it must also be simple and flexible. The topic of recharging is still relatively unknown to many people, but will play an important role for electric cars. Mechanical assistants can help people here by charging their vehicles for them. One example is the charging assistant from KUKA, a new development resulting from a cooperative venture with Volkswagen Corporate Research.

One variant of this product can be used in private garages. To put it simply, the charging assistant automatically plugs the connector of the charging cable into the socket of the electric vehicle on request. The driver parks the car inside a generously dimensioned ‘parking window’. The charging assistant takes care of the rest. “In this way, the vehicle is ready to use again as quickly as possible,” says Elisabeth Schärtl, Senior Innovation Manager at KUKA. “The charging assistant is also a solution for a wide range of different areas of application, such as vehicle pools or car parks, in which the confined space available would make manual charging virtually impossible.”

Today, the charging assistant may appear to be a convenient extra for the vehicles currently available. In the future, however, autonomous driving will play an ever greater role – as will functions such as autonomous parking. This will make automation of the charging operation more important – and the charging assistant for the cars of the future will increasingly become an everyday object.

Overview of industrial robot types

Gantry

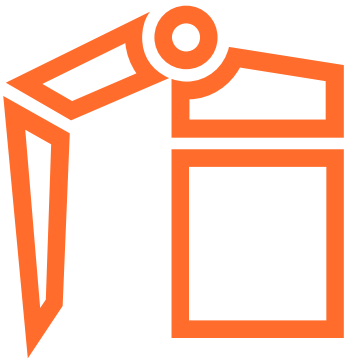
Gantry robots can transfer loads over long distances and position them with great precision. Smaller versions of gantry robots also exist in pick-and-place machines. Gantry robots load machines from above, for example via loading hatches – so the machine remains accessible. Different gantry robot variants are available. The simplest variant is the linear gantry. Here, the points to which the gripper can be moved are located in a single axis. The gantry arm is responsible for the vertical motions while a gantry slide performs the horizontal motions. If a perpendicular motion is also required, a cantilever gantry is used. A Cartesian gantry robot can cover large areas.

Delta

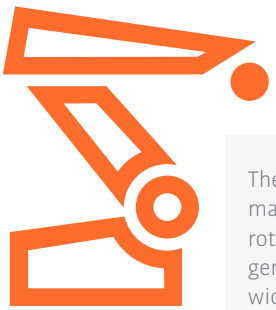
The shape of these robots is reminiscent of the Greek letter delta. They are parallel arm robots with tripod kinematics and their arms are connected to universal joints at the base. A key feature of delta robots is that their main drives are fixed on the frame. Moreover, they generally have three or four degrees of freedom. The base of the robot is mounted above the moving parts, i.e. suspended from the ceiling. The jointed arms – at least three – start here and are connected to a small triangular platform at the other end. Delta robots are fast and light and are thus frequently used for packaging and assembly tasks and in high-speed applications. Thanks to their precision, they are suitable for pick-and-place tasks, while their speed means that they are also suited to very high-volume applications in the pharmaceutical industry. Delta robots have a limited working envelope and a low maximum load capacity.

Palletizing robot

This robot automatically places pallets and packages on load carriers. It comes in various types, such as the layer palletizing robot. Palletizing robots generally have four degrees of freedom. They are very powerful and are used to place entire loads on a pallet. The tool flange of the palletizing robot, and thus also the tool itself, always moves parallel to the floor.



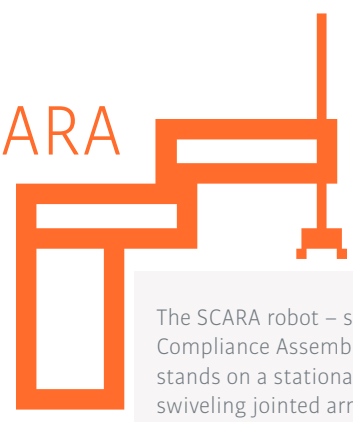
Hundreds of thousands of robots are in operation around the world every day. Their appearance is as varied as their tasks. Here we present a few of the most important representative types:



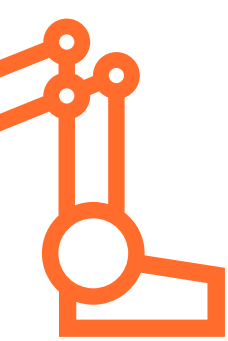
Articulated

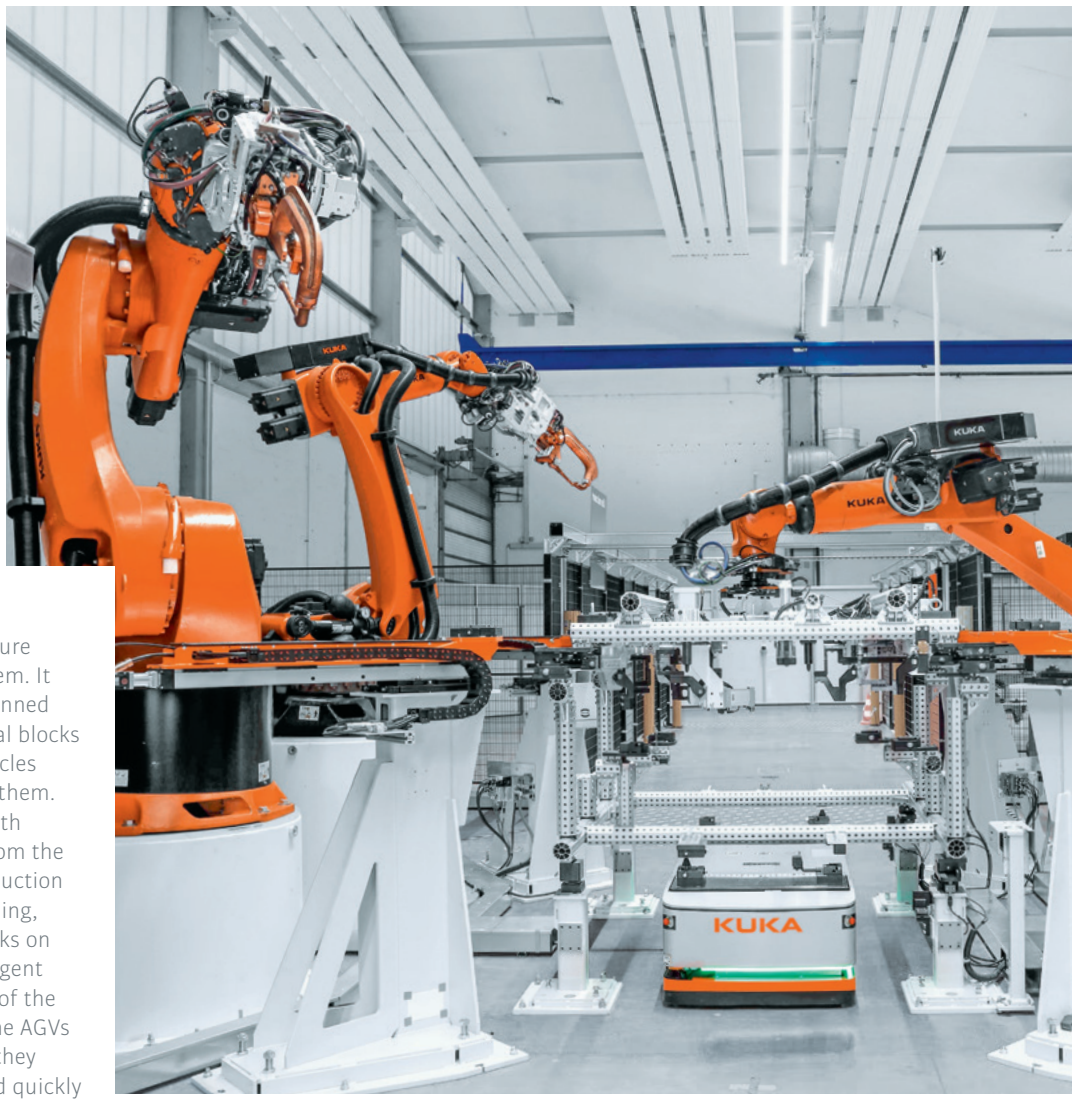
The archetypal robots in industrial manufacturing, articulated robots have rotational main axes and can thus generally move freely in space. The most widespread design has six axes, while a seventh axis basically enables the robot to 'work around the corner'. In order to extend the working range still further, it can be mounted on a linear axis, thus covering longer distances or serving multiple work stations. Articulated robots – including dual-arm systems – are primarily used for flexible tasks, particularly ones involving complex motion sequences. The robot can perform a wide range of tasks, such as assembly, palletization, spot welding or painting.

SCARA



The SCARA robot – short for Selective Compliance Assembly Robot Arm – stands on a stationary base and has a swiveling jointed arm with three vertical rotational axes. SCARA robots are also characterized by the fact that they have fewer than six degrees of freedom – normally four. At the end is the vertical and rotational Z axis on which a gripper can be mounted. Typical tasks are horizontal transfer and vertical joining. The robust robots can be installed on the floor, wall or ceiling. SCARA robots require little space and have high repeatability. However, they can only be used for low payloads and a small workspace.





KUKA showcases the possibilities of intelligent production in Augsburg with the SmartProduction Center. New approaches to systems engineering have been derived from matrix production.

Smartening up production

Production of as many different products as possible in a single system with the shortest possible conversion times – this is something that companies have been dreaming about for a long time. One solution: a neutral, intelligent system that can use diverse, changeable tools to produce a wide range of different things.

The production facility of the future does not resemble a typical system. It looks more like an accurately planned network of streets with individual blocks and with automated guided vehicles (AGVs) moving around between them. They fetch tools, equip robots with them and supply components from the warehouse to the block-like production cells. There, robots perform welding, screw fastening and bonding tasks on the different components. Intelligent software maintains an overview of the whole system. It knows where the AGVs are located, which components they need to deliver to the robots, and quickly prepares a conversion.

Increasing type variety, more frequent changes of model and fluctuating production quantities: in a fiercely competitive market, such flexible solutions are of decisive importance. Quickly adaptable production cells are replacing rigid systems, where the conversion can take many weeks or even months.

The flexibility is based on a programmable material flow, explains Dr. Andreas Bauer, KUKA Software Development Team Leader. “In smart production, parts logistics and production are separated from one another. The different areas are linked together as required by automated guided vehicles and intelligent software.” The production cells are equipped with neutral equipment. This interaction enables simple scaling of production or

> The challenge is actually to make use of the new possibilities. «
>
> Dr. Andreas Bauer, KUKA Software Development Team Leader

rapid adaptation to new products. In this way, a single system could be used to produce a washing drum or a wheel arch for automobiles.

Production know-how and industrial service as a business model?
Prof. Dr. Wolfgang Maaß heads the Smart Service Engineering department as Scientific Director at the German Research Center for Artificial Intelligence (DFKI). He sees the gain in flexibility primarily as a chance for innovative business models. While issues such as predictive maintenance techniques and condition monitoring are important aspects, they mainly serve the purpose of cost optimization. Maaß sees the creation of innovative business models particularly where companies are prepared to transform themselves: "This can be an expansion to include additional branches of industry or product ranges."

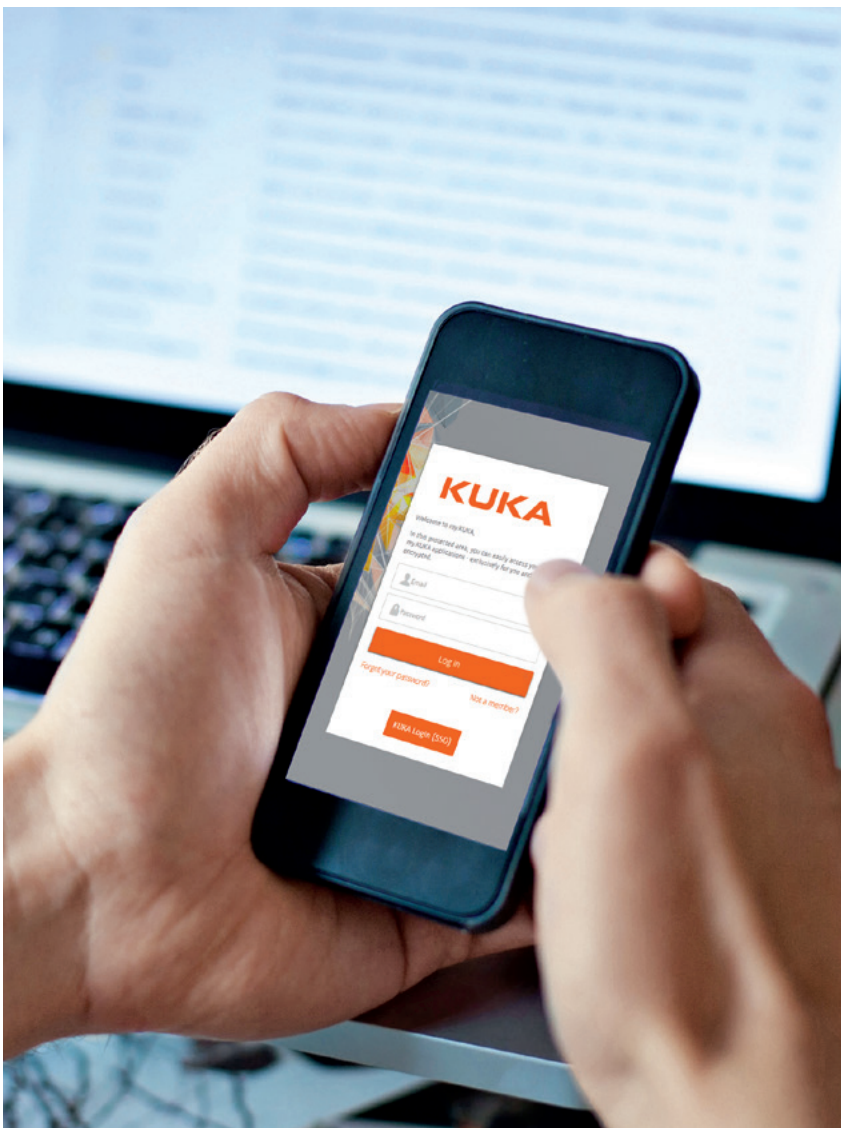
In a smart production facility with its networked machines, large quantities of data are naturally generated – a further benefit for the companies. DFKI is investigating how production data and know-how can be traded and recognized on balance sheets. Here, once again, there is scope for an innovative business model: "Data about the quality of incoming raw materials and semi-finished products or wear to tooling and machinery over time, for example, can be analyzed and condensed to knowledge which can then be sold."

In the future, support services could also be generated in a production shop, explains Bauer: "Smart production, with its freely programmable sequences and conversions and intelligent software, enables Pay-Per-Use and X-as-a-Service business models." This means that a company no longer sells a specific product, for example, but offers its system infrastructure as a service.

Bringing supply and demand together: ARENA2036
One example of such innovative models is the research campus ARENA2036. The versatile research shop is part of the campus of the University of Stuttgart and functions according to a familiar principle: the world's largest ride-hailing company UBER does not own a single vehicle, the world's largest accommodation-sharing provider airbnb does not own a single bed – the trick is to bring supply and demand together.

This is also the task performed by ARENA2036, explains Peter Fröschle, Chairman: "We do not employ researchers of our own, but function as a broker of research projects and collaboration opportunities. We provide the building and thus a project area for the cooperation, for example. In ARENA2036, the expertise of the different partners is bundled, accelerating the process from the idea to its implementation." In other words, a research campus in which partners from the worlds of science and business can jointly research and shape topics such as mobility, production and work in the context of digital transformation.

Smart solution of challenges
A certain degree of creativity is required to change our thinking away from established, traditional processes and towards automated guided vehicles and smart software. "To put it in a nutshell, the challenge is actually to make use of the new possibilities and not to be limited by prevalent notions of what can currently be achieved in terms of flexibility using conventional controllers," says Bauer.



Logging in instead of talking to someone?

About digitized sales channels and complex products

User name and password: two entries that take many people from the analog world to the digital world on a daily basis. They open the door to online services, order histories or invoices. Online banking and online shopping are typical examples. But what if more complex products – so-called capital goods – could also be ordered online and the cooperation between sales employee and customer were to become increasingly digital?

e-commerce

Electronic commerce (e-commerce) is trading that is carried out on the World Wide Web. Electronic trading made its debut in the online portals of the 1980s. The term does not refer solely to buying and selling on the Internet, however, but also to additional services, such as those offered in the fields of customer service and online banking. The emphasis is on electronic business transactions in the B2C and B2B sectors.

Printing out bank statements, setting up a standing order at the bank counter and filling out transfer slips by hand are all actions that are disappearing more and more from everyday life. 76 percent of Internet users make use of online banking. That is the finding of a study conducted by the digital association Bitkom in May 2018. “It is interesting to observe that sales channels in the consumer sector are already highly digitized, whereas the channels to corporate customers are still predominantly offline,” says Prof. Dr. Christian Locher, who teaches Digital Business at THI Ingolstadt (University of Applied Sciences), and adds: “Corporate customers do use online banking, but when it comes to consulting, this is often still carried out offline. In my view, the reason for this is quite simple: corporate customers’ problems are highly complex and specific.”

This could be one of the reasons why, so far, it is primarily short-lived consumer goods that have been traded online. “The technical possibilities of e-commerce will not remain unused, even for products that require more consultation,” affirms Dirk Engelbrecht, Digital Business Manager at KUKA. “A good comparison is with the configuration of vehicles. The customer is not interested in individual parts of the bodywork, but is guided by the desired functions of the vehicle. One major challenge facing the operators of digital sales channels will thus be to abstract the complexity of the products, keeping it away from the customer.” If the value chain all the way down to product sales becomes ever more digitized, both customers and suppliers could benefit from this. The services available can be used at any time. The high administrative effort would be considerably reduced and precisely these tasks could be carried out more quickly and effectively.

“It is conceivable that, in the future, the industrial robot could be a kind of platform that has capabilities which are provided as services. A software ecosystem would be formed around it and could be used to add new functionalities,” says Locher. “Naturally, the greater the standardization of the product, the less important a specific industrial robot will become and the more one will select the right solution as a whole.” The question that arises here is this: at what stations along the customer interaction process should the sales employee be supported by the use of modern technology? Some tasks could be performed less expensively and more effectively using digitization. Ideally, online and offline activities would have to complement one another meaningfully. “The role of sales employees as comprehensive solution consultants will develop faster and more clearly. The digital sales channel will then support these colleagues in processing administrative tasks and enable targeted expansion of broad specialist expertise,” says Engelbrecht.

Christian Locher, whose research includes the question of how companies need to position themselves with regard to digitization, has a similar view: “The human consultant has a very important function. He understands the customer and his business. He understands his problems and can thus identify the right sales approach and begin to develop a solution. In this respect, he is naturally also the key to sales success.”

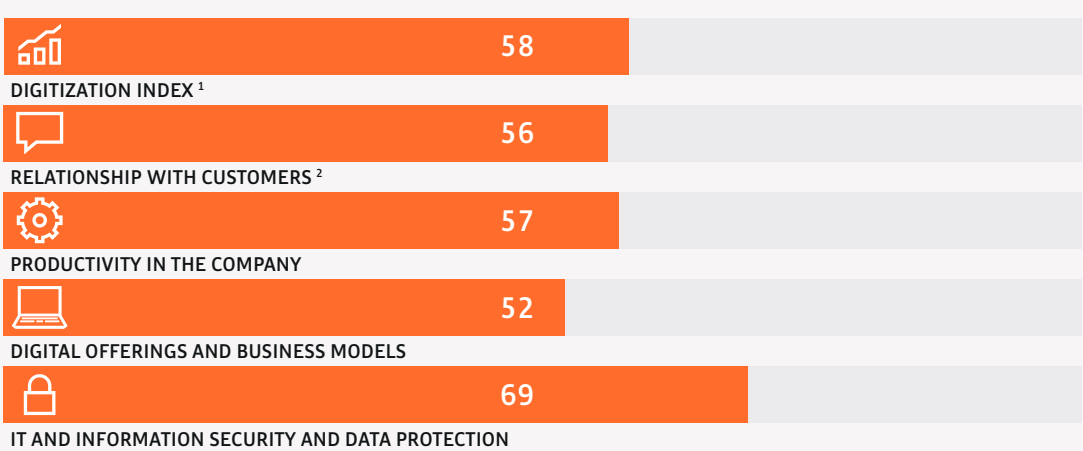
Industrial SMEs currently achieve 58 out of a possible 100 digitization index points. That is the finding of the study ‘The digital transformation in German SMEs’ conducted by techconsult for the third time in November 2018 on behalf of Deutsche Telekom. The degree of digitization in different areas of activity involving relations with customers reaches 56 out of a possible 100 points. According to the study, about half of industrial companies are now investing in the digital competence of their employees in order to accelerate digital transformation. “To enable sales channels to be digitized successfully, it is essential that all sales employees understand digitization. The main task will be enthusiastically conveying to customers the new possibilities created by digitization. This will necessitate training in digital media,” says Locher, stating the prerequisites for successful transformation. “One very important target group is new, young employees who are currently joining SMEs and looking for digital solutions there. Companies must create offers for this target group,” says Engelbrecht, adding: “Sales employees will have an essential role to play in customer relationships. The word ‘relationship’ is decisive here. Without a basis of trust in the supplier, capital goods will still not be procured digitally in large quantities in the future.”

» Corporate customers do use online banking, but when it comes to consulting, this is often still carried out offline. «

Prof. Dr. Christian Locher, who teaches Digital Business at THI Ingolstadt (University of Applied Sciences)

SME digitization index 2018

THE REACH OF DIGITAL IN INDUSTRY



[1] Average degree of digitization in industry according to the SME digitization index (Digitalisierungsindex Mittelstand), max. of 100 points possible
[2] Degree of digitization in various fields of activity

Source: SME digitization index, Telekom Deutschland and techkonsult, November 2018

Did you know? What language machines speak

"I am an industrial robot and I have six axes." One language that machines in production shops use to describe themselves and to communicate with one another is called OPC UA. OPC UA stands for Open Platform Communications (OPC) Unified Architecture (UA). Rather a mouthful for something that is very useful. After all, the fact that machines in production shops are able to communicate with one another and exchange data forms the basis for the Industrial Internet of Things.

According to the German Engineering Association (VDMA), OPC UA is the designated standard for the communications technology and language of machines. It makes it possible for any quantity of data to be made available and exchanged uniformly. The task of OPC UA? The standard defines how these data are translated into a machine-readable form – reliably and irrespective of the manufacturer. For industrial data exchange in real time, OPC UA is expanded to include the standard TSN. Time-Sensitive Networking is another relevant technology. The main features: TSN enables time synchronization down to the microsecond and the simultaneous transmission of multiple protocols while reserving transmission channels for messages that have to be transmitted in real time.

The forecast: OPC UA TSN will become the industry equivalent of USB. The standard will be used wherever sensors, actuators and controllers from different manufacturers form a shared network. In exactly those situations where a large number of machines and components have to talk to one another. In short: OPC UA TSN enables machine and system builders to implement the digital transformation of their production facilities.

Language of machines

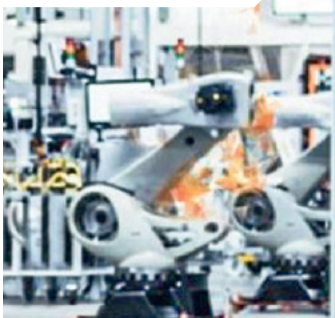
IIoT: Industrial Internet of Things

M2M: Machine-to-Machine

OPC: Open Platform Communications

UA: Unified Architecture

TSN: Time-Sensitive Networking



So easy and yet so difficult

When robots learn to see

Image processing systems endow machines with the ability to see and understand.

The robot moves over a box with colorful building blocks of different shapes, deliberately picks up a yellow triangle and sets it down next to the box. This is a process that could hardly be easier for a human, but one that has posed major challenges for robot programmers since the 1980s: bin picking, as it is called, is one of the most difficult tasks in robotics. It is not the actual picking up and setting down that poses problems. The difficulty is in recognizing unsorted objects. This is because the robot lacks one of the most important human abilities: vision.

The German Duden dictionary defines vision as 'the act of perceiving (by means of the sensory organ eye)'. How is a machine supposed to use this ability when it is lacking this sensory organ? The solution is to be found in image processing systems. Image processing works in a very similar way to human vision: neither humans nor machines actually see the object itself but rather the reflections of light bouncing off the object. In humans, the iris, pupil and retina bundle and focus the light and present it in colors. This information is then forwarded to the brain. In a machine, these steps are performed by cameras, apertures, cables and processing units.

Perception is the difference

"Despite the many similarities between human and technological vision, there are major differences between the two worlds," explains Anne Wendel, Director of the Machine Vision Group at the VDMA Robotics + Automation association. "The greatest difficulty is understanding and interpreting image data. In the course of their lives, humans learn the meaning of objects and situations that they perceive with their eyes on a daily basis and filter them intuitively for the most part. By contrast, an image processing system only identifies objects correctly if they have previously been programmed or trained." The brain of a small child can distinguish between apples and pears just as quickly as between a cat and a dog. The same task is very difficult for a technological system.

To enable the correct identification of objects, there are software algorithms for a wide range of different tasks. In order to program these correctly, the

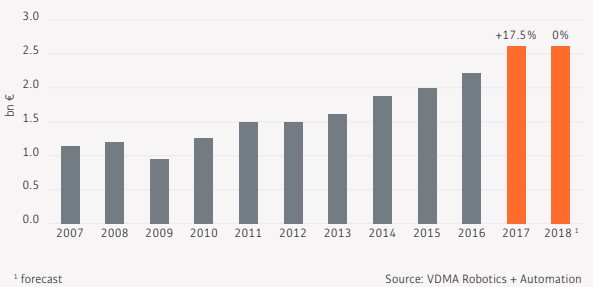
Vision systems help the robot during bin picking.

developers of image processing systems must already know in advance what the system will subsequently have to achieve for it to be designed accordingly. “Deep learning – the use of artificial neural networks – allows images to be classified with better success rates than previous methods and can be of help here,” says Wendel. Good results can be achieved, particularly where standard applications are concerned. However, a large quantity of image material is required – normally far more than the production process provides, especially of defective parts.

Deriving actions from information

According to KUKA vision expert Sirko Prüfer, the combination of image processing and robotics goes a step further: “We actively involve the robot in the so-called ‘perception-action loop’. It is not enough for us to capture the information from the image. We concern ourselves with what action can be derived from the information for the robot.” In combination with mobility, this can open up new fields of application: from the robotic harvesting of highly sensitive varieties of fruit and vegetables to applications in the care sector that require comprehensive recognition of a room.

Machine Vision Germany: record level maintained



1 forecast

Source: VDMA Robotics + Automation

Another major topic of the future is that of ‘embedded vision’, in other words the direct embedding of image processing in end devices. One example is assistance systems in cars and autonomous driving, which are impossible without integrated vision systems. Embedded vision is making inroads into fields of application that could not previously be tapped using smart cameras or PC-based systems. Value creation is shifting further from hardware to software.

Whether bin picking, automated harvesting or the use of embedded vision, all these applications require a high level of processing capacity for the image processing. Edge and cloud computing concepts will play a pivotal role here in the future. Data protection and data security are issues that arise here, and ones in which image processing expert Wendel sees challenges: “As in many other areas of production, there is a fundamental question: Who owns the network? And the data? And the condensed reproduction of the data?” This is an area that remains to be clarified. The challenges demonstrate just how superior human vision and judgment still are to their technological counterparts. Even if bin picking solutions are constantly improving: there is no substitute for the human eye.

> **» Despite the many similarities between human and technological vision, there are major differences between the two worlds. «**
>
> Anne Wendel

Recipe for successful production?

Instead of cheap mass production, there is increasing demand for customized products. This is turning old manufacturing models upside down. But how can companies rise to this challenge?

Read more on page 22

Strong together for innovations

Germany is the world champion in innovation – but this title should be no cause for complacency. One recipe for innovation: cooperation between research and industry.

Read more on page 28

Smart cities

Around the world, more and more people are moving into cities. Smart logistics concepts can help to keep urban areas worth living in: smart supply instead of noise and air pollution.

Read more on page 30

Imagine

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All about trends, developments and the technologies of tomorrow.

Future-proof healthcare sector

The shortage of skilled labor and the aging of society are an enormous challenge for the healthcare sector. Robotics and associated technologies can help to resolve urgent problems and relieve employees.

Read more on page 24

»Unfortunately, there is no crystal ball«

Three factors for successful production

Long-lived models, few variants and a product range determined by the manufacturers: that is what day-to-day production used to be like. Today, customers have different expectations. How can companies rise to this challenge? Three factors are of decisive importance here.

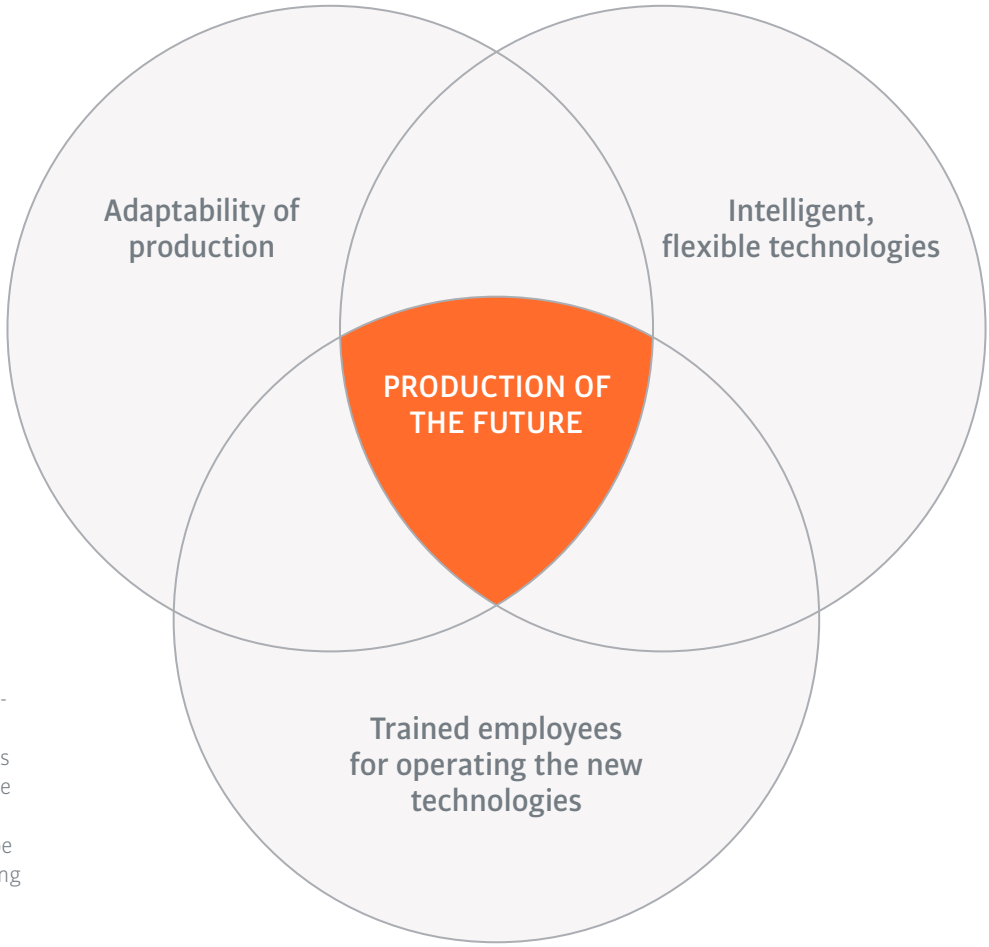
Everybody is familiar with this everyday scenario: customers expect a new product to be configured to meet their own requirements as far as possible. It should also be inexpensive and available as quickly as possible. This was not always the case. "In the past, production was driven by supply. In other words, customers had to make do with what companies offered. The products were offered over a long period of time and variant diversity was low," explains Prof. Dr. Dirk Jacob from Kempten University of Applied Sciences. This resulted in manufacturing based on mass production. Factories were located wherever production costs were lowest.

Megatrends are turning old manufacturing models upside down

"Today, we are faced with the megatrends of digital transformation, customization, an aging workforce and manufacturing with a minimized impact on resources," explains Jacob. These megatrends affect all sectors. Companies in the B2B sector are also responding, as their customers expect greater flexibility. This finding is backed up by the study 'Zeit zum mutigen Handeln' (Time to act boldly) conducted by the auditing and consultancy firm KPMG in 2017. The result: companies in the manufacturing industries must heed changes in supply and demand while also taking technological innovations into account if they want to remain competitive in the long term and to be able to meet increasingly individual customer requirements at all times.

> »Today, we are faced with the megatrends of digital transformation, customization, an aging workforce and manufacturing with a minimized impact on resources.«

Prof. Dr. Dirk Jacob from Kempten University of Applied Sciences



Let's take the example of cell phones: already today, a mobile phone stays in production for a maximum of one year. It is then superseded by the next generation. Unfortunately, there is no crystal ball that enables us to look into the future and predict the next developments. It will thus be necessary in the future to respond to trends as quickly as possible. For this, manufacturers require state-of-the-art production lines. At the same time, the workforce will have to be able to keep up with the rapidly changing product variants.

Three factors will determine the production of the future

The key to responding to megatrends is fast, flexible production. Three factors are of central importance here. Factor one: intelligent and highly adaptable technology. Production lines based on machine tools, 3D printers or robotic systems provide the required flexibility for responding to changing production requirements. It is important for machines and robots to be equipped with open interfaces in order to allow optimization from any location, for example via the cloud.

Factor two: the human factor. The focus is increasingly on humans, as they have to be able to operate and convert machines easily – even if different products are manufactured on a line in quick succession. With advancing age, skilled workers also require relief from physically strenuous activities.

Factor three is comparatively new in production: adaptation. Production technologies will adapt to continuously changing requirements and this ability will increasingly determine a company's competitiveness. A comprehensive network of experts, open platforms and interfaces can help here. In order to ensure that their production shops always conform to the latest state of the art, companies will increasingly be setting up communities and app store platforms. The machines themselves will be updatable. The result is a living ecosystem comprising a wide range of different firms.

"A robot is essentially flexible and durable, but must also be equipped in accordance with the specific task in hand. The community continuously develops new software or hardware that the companies can use to respond quickly to the current trends. A single company cannot achieve this alone," says Jacob. The objective: to combine these three factors for fast and sustainable local manufacturing with a minimized impact on resources.

OP assistants, diagnostic assistants, mobile robotics platforms

New technologies – the solution for the healthcare sector?

A small robot travels independently through hospitals, bringing patients their medicine. We could be encountering such helpers in hospitals more often in the future. The goal: optimal treatment for people.

Autonomous service robots offer support in hospital logistics. This gives nursing staff more time to look after their patients.

People in industrialized countries are getting older, there is a lack of skilled workers and care personnel are overworked: these are challenges that all areas of the healthcare industry have to face. New concepts are required in order to ensure comprehensive care for the increasingly aging population in the future. This entails more efficient processes since the requirements in terms of quality and documentation are growing. At the same time, personnel must be provided relief so that nurses, care personnel and doctors once again have more time for patients.

"We need holistic automation solutions enabling us to tackle the numerous challenges in the healthcare sector," says Stephan Sonderegger, CEO of Swisslog Healthcare. "This is why we are helping our customers in the healthcare industry not only to boost their efficiency, but also to free their personnel from administrative tasks."

One example is individually sorting the correct medication for each patient. What used to be a time-consuming, error-prone task for nursing staff will now be handled by robots in the central pharmacy in a hospital and autonomous service robots (ASRs) or pneumatic tube systems will transport them to the nursing station. According to Ohio State Medical University, this could save 160 work hours each day – time which would remain for personal contact with patients.

"The future of hospitals is in robotics technology"

Stefano Stramigioli, Professor of Advanced Robotics at the University of Twente and ITMO University, sees further fields of application: "Not just in logistics, but also in areas such as diagnostics, the future of hospitals is in robotics."

The precision of robots brings decisive advantages for the patients – regardless of whether this is in radiology, endoscopy or during what is called keyhole surgery, where operations are carried out more or less within a closed abdominal or chest cavity without large incisions being needed. "Here, the quality is what matters. Surgeons urgently need a system which they can reliably work with. And that is only possible to this extent with robots," explains Stramigioli. With the KUKA LBR Med, for example.

KUKA Innovation Award: new ideas for the healthcare sector

The theme of the 2019 KUKA Innovation Award is 'Healthy Living'. The participating teams are implementing their projects using the LBR Med – the first robotic component worldwide to be certified for integration into a medical product. From back massages to robot-assisted laser treatment and onto the treatment of micro-fractures: there are many different areas of application.

Want to learn more about the KUKA Innovation Award? Visit us at www.kuka.com/innovationaward

The lightweight robot is the first robotic component worldwide to be certified for integration into medical products. Capable of human-robot collaboration (HRC), the robot technology is tailored to the specific requirements of the medical sector.

'Maximizing potential' thanks to medical robotics

One example illustrating this trend is the EU research project MURAB for, among others, enhanced cancer diagnostics. Thanks to the sensitive KUKA LBR Med lightweight robot, it is possible to improve biopsies by having the robot provide support in the precise control of the biopsy needle. Robot technology thus minimizes costly magnetic resonance imaging. "This is a really promising project. The precision of the robots allows us to maximize the potential of imaging processes," says Stramigioli.

Whether for transport tasks, as a surgical assistant or even as an aid for repositioning patients – ultimately, all robotics and automation projects serve a single purpose in the healthcare industry: making treatment as gentle and as effective as possible for the patient. To achieve this goal, new technologies support doctors and care personnel, ensuring the healthcare sector is fit for the enormous challenges of the future. Sonderegger stresses this as well: "Automation allows more time for care and thus for the patient – the human being is the focus. Patients recover faster and health costs can be reduced.

Robots such as the lightweight robot LBR Med support physicians as intelligent assistants

Pneumatic tube systems transport medication fast and effectively

We are already counting on new technologies today here in the healthcare sector

Gentle – thanks to Da Vinci

The operation system Da Vinci enables a particularly gentle treatment of bowel cancer through minimally invasive high-precision technology. Robot arms with endoscopic micro-instruments carry out the movements of the surgeon at a control panel in real time.

'Andago' increases mobility

In the Clinic for Geriatric Rehabilitation at the Robert Bosch Hospital in Stuttgart, older patients can train to perform everyday movements and balancing exercises with the 'Andago' robot. The robot intuitively follows the person's movements and thus helps to significantly improve the patient's mobility and well-being following neurological injuries.

Swisslog Healthcare Technology Center

The Swisslog Healthcare Technology Center in Colorado provides solutions and support services for improving the medication supply chain and optimizing workflows for clinical personnel. In the center's own 'Solutions Experience' with adjoining college, the complete, automated process of the medication management system can be realistically learned, experienced and evaluated. What is more, the world's largest pneumatic tube system installation is located there and can be used by multidisciplinary research and development teams for testing purposes. The Technology Center is also a production and distribution center for the manufacture, assembly and sale of Swisslog Healthcare pneumatic tube systems as well as a customer care center for technical support.

The virtual knife

The European Cyberknife Center in Munich-Grosshadern treats patients using a special, technically complex form of radiotherapy: the Cyberknife method. In this, a robot-guided radiation head destroys the tissue of the tumor. The special feature here is that the surrounding healthy tissue is spared as much as possible – which, in turn, makes the treatment as tolerable as possible for the patient.

Hand in hand

How technology transfer advances research and industry

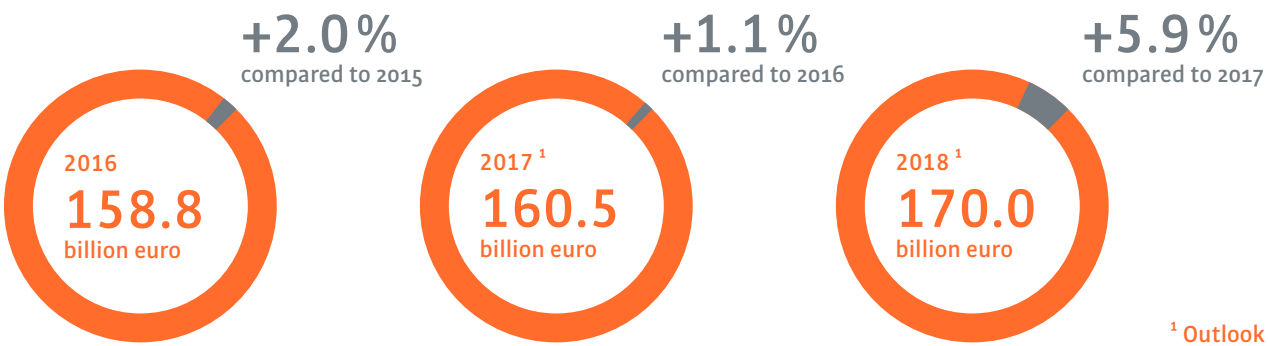
Germany is the world champion when it comes to innovation: no other country in the world is as innovative – that is one of the conclusions reached by the World Economic Forum in its Global Competitiveness Report 2018. The German Federal Ministry for Education and Research (BMBF) also has good news to report in this respect: innovation expenditures of German companies rose to a record value of 158.8 billion euro in 2016. No other European country spends as much on innovation. Germany is thus in an outstanding position in the fields of research and innovation. Resting on one's laurels is not a good idea, however: this leading position can only be maintained by increasing digital education and improving the transfer of good ideas into practical applications. KUKA Corporate Research also focuses on this technology transfer and works hand in hand with research institutions from around Europe on numerous projects. Let us present a few exciting examples:

fast robotics

The goal of the project is fast wireless communication between robots, but also with sensors, as today's wireless communication systems often lag behind the needs and requirements of industry. The findings of the project will be particularly important in the future if mobile robots are to form groups with one another or with other stationary sensors and actuators and then to cooperate dynamically. In this funded project, work is being carried out on the development of an innovative control concept. This is intended to enable both mobile and stationary robots to be monitored, localized, configured and controlled via a mobile telecommunications infrastructure. In this way, intelligent networking will make for greater flexibility.

BaSys 4.0

Production processes that can be transformed efficiently are one of the central challenges in Industrie 4.0 for staying competitive at an international level. Products are being manufactured with ever more variants and in ever smaller batch sizes, while production costs have to be kept as low as possible. The BaSys 4.0 project funded by the German Federal Ministry for Education and Research aims to address precisely this issue. The objective is to develop a basic system for production facilities that will enable the efficient adaptability of production processes. Within this project, KUKA is focusing on the integration of robot technology.



Innovation expenses of German companies (Source: BMBF)

RoSylerNT

The BMBF-funded project RoSylerNT is developing interactive robotic training systems for physical and cognitive stimulation. The goal is to develop a robot that could serve as a training partner in rehabilitation, for example. For this, the learning robot needs to possess basic skills in order to perceive the posture and movement of, and strain on, the human patient. This will enable the robot to adapt to the individual person, their performance capability and the specific situation. The attending physician can then use the newly gained time more effectively and deal more intensively with the concerns of the patient. The newly developed basic skills can also be transferred to domestic or occupational scenarios and provide meaningful support to people in these areas. In particular, the learning algorithms make it possible to address the physical performance capability of older people. Robots as assistance systems can use their technologies to enable safe, autonomous training and provide support for the handling of heavy objects in the home.

REFILLS – Robotics Enabling Fully-Integrated Logistics Lines for Supermarkets

Half of supermarket intralogistics costs are incurred as soon as the goods are in the store. The goal set for the EU-funded project is to reduce these costs. REFILLS aims to shorten the distances traveled by the staff and to facilitate shelf-filling by means of improved ergonomics. A mobile robot system is used for this. First, the current inventory is scanned and the product data are saved. A robot system then helps the human employee to stack the shelves. Any surplus goods are returned to the warehouse autonomously. From there, refilling is carried out as the final step. REFILLS may help to ensure that supermarket automation is not merely restricted to bottle deposit return systems in the future.

SeRoNet – Service Robotics Network

The Service Robotics Network funded by the German Federal Ministry for Economic Affairs is an online platform that enables users, system integrators and manufacturers of components for service robot solutions to work together efficiently. They can use SeRoNet for jointly supporting solutions from the requirements analysis through to operation. This applies to the areas of logistics, nursing care and healthcare, but also to assembly assistance at manufacturing companies. Manufacturers, system integrators and end users are networked and can thus cooperate with one another. The customer describes his problem here and then looks for the appropriate system partner. This can significantly reduce the development effort for customer-specific solutions. It is not only end users and system integrators, but also operating companies and above all small and medium-sized enterprises without existing sales networks that can benefit from the platform. This enables them to open up new markets, for example.

»A city is brought to life by its inhabitants and their supply infrastructure.«

Already today, more than half of the world's population lives in urban areas. It is estimated that a further 2.5 billion people will be crowding cities by 2050. The figures contained in the UN report 'World Urbanization Prospects 2018' raise the question of how urbanization can be shaped successfully for all involved.

"A city can be considered as 'smart' if it is worth living in," says Dr. Christian Baur, CEO of Swisslog Logistics Automation. In his opinion, the cities of the future have to be one thing above all else: sustainable. "A city is brought to life by its inhabitants and their supply infrastructure. Residents want to consume goods and the goods that they consume have to be delivered. As quickly as possible and without major effort. This delivery process naturally entails heavy traffic and thus noise and air pollution. In order to make the cities of the future a habitat worth living in, we thus need new concepts for city logistics."

More deliveries, new challenges
That is also the view of Dr. Christian Jacobi, Managing Partner of management consultants agiplan, Board Member of the German Logistics Association (BVL) and spokesman of the BVL working group on urban logistics: "The urban logistics sector does not merely share responsibility for ensuring that the city of the future simply functions, but is also challenged to provide a healthy habitat worth living in." For this, the movement of goods must be reorganized. "This must be achieved in such a way that there is no impact on trade, emissions are reduced, and raised customer expectations, such as same-day delivery and punctual fresh food deliveries, are met."

4.15
billion consignments
annually (until 2021)

URBAN DISTRIBUTION CENTERS/CITY BORDER

SWISS POST
FedEx
TNT
DHL
UPS

This is a major challenge for cities. After all, according to an online survey on the topic of city logistics conducted by real estate consultancy Colliers International, almost 10 million packages are delivered daily in Germany alone. By 2021, the German Package and Express Logistics Association expects this figure to rise to 4.15 billion consignments annually. Demand for fast and, above all, customized deliveries will increase and distribution logistics will face new challenges.

Faster and more flexible with urban logistics
"That is where we come in. We want to exploit our know-how as a logistics expert and integrate our concepts into the smart cities of the future," affirms Baur. The Swisslog SynQ software that is already used for warehouse management worldwide could be deployed, for example, in so-called urban distribution centers. Goods could be produced, stored and shipped from municipal warehouses shared by different vendors.

Furthermore, work is being done on local delivery hubs which will be set up like large parcel drop-off points at central locations in the city, such as major companies or universities, where parcels can be picked up and returned. Everything will run fully autonomously – controlled once again by the SynQ software.

New concepts with project partners in the postal sector

Swisslog expert, Paul Douglas: "The idea is to set up small warehouses in larger cities to take over the so-called 'last mile' delivery. The QTainers will be located at important junctions where many people pass by and where the infrastructure for delivery is available."

Today, **55 %**

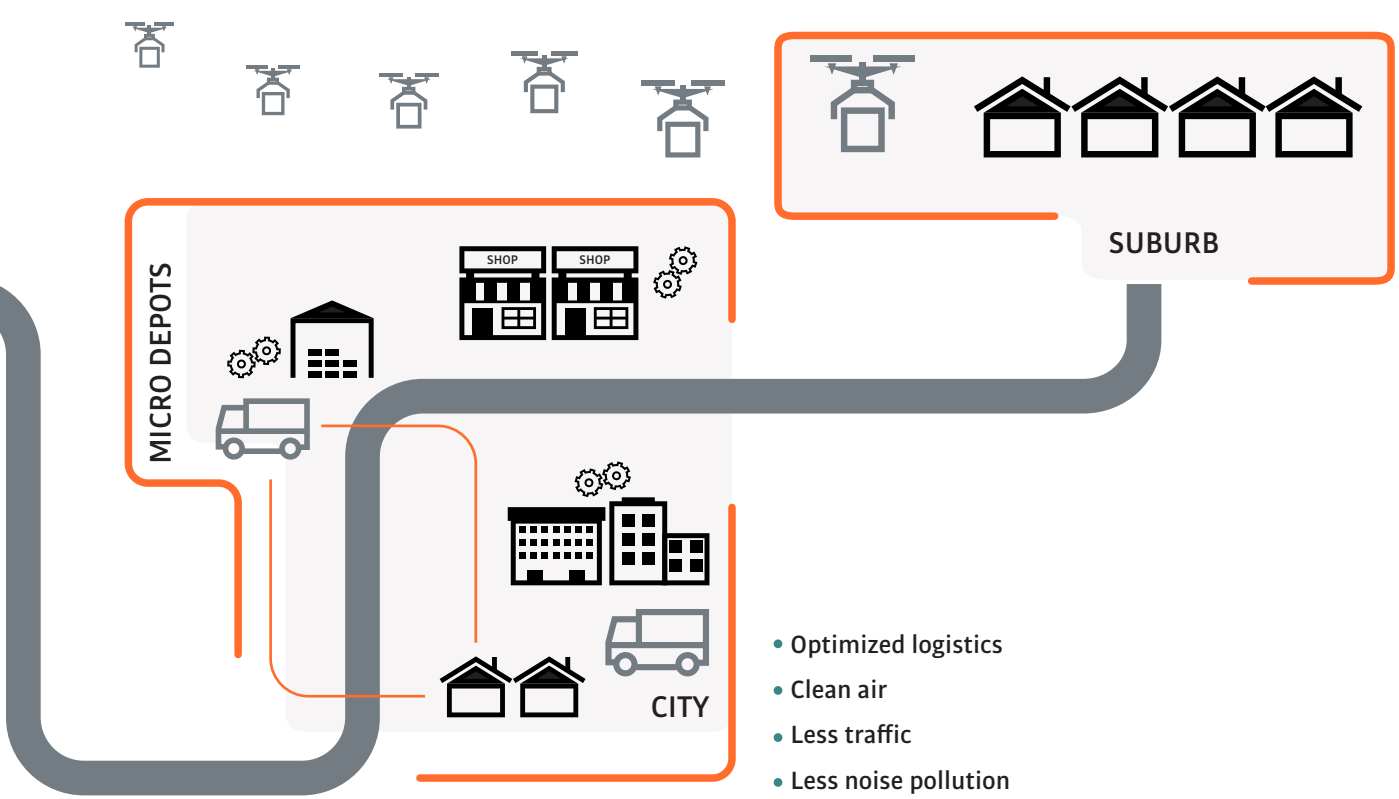
OF THE WORLD'S POPULATION

lives in urban areas.

By **2050**, this figure will rise to **68 %**.

Marc Hasler, Head of Product and Market Development at PostLogistics, is responsible for city logistics at the Swiss Post Office: "There are many different approaches in city logistics: one possible approach is to use stationary or mobile transfer sites – so-called hubs. Hubs are set up at central points in Swiss cities and used by one or more different logistics service providers. Within the cities, final distribution could be carried out collectively by a single logistics service provider – rather than each provider acting separately. The goal is to achieve minimal impact on the road network together with fast and flexible delivery despite peak traffic times. The Swiss Post Office already successfully tested this approach last year in Zurich."

The important thing to note with regard to smart cities is that there is no single concept that will function universally in the same way in every city of the world. What is clear in every case, however, is that every concept invariably has repercussions for municipal infrastructure. This infrastructure must become smart, particularly with a view to making life in the city attractive in the future. City logistics is a central element in achieving this objective. After all, a city is brought to life by its inhabitants – and they need an adequate supply infrastructure.



- Optimized logistics
- Clean air
- Less traffic
- Less noise pollution

The 1000 faces of robotics

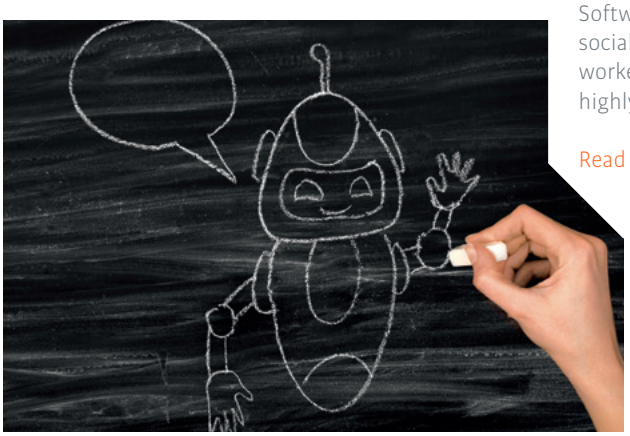
Assistant for astronauts, underwater snake or fun ride in an amusement park: robots are more than just assembly line workers in industrial factories. An overview of some unusual representatives.

Read more on page 42

Artificial intelligence – all just hype?

Everyone's talking about artificial intelligence – and not without controversy. While some see it as a problem solver for a wide variety of different tasks, others regard it as a potential threat. In this interview, AI expert Prof. Torsten Kröger addresses the true potential of AI and what we need to consider when dealing with it.

Read more on page 44



What is a robot?

Software assistant and artificial user in social networks or heavy-duty industrial worker: the definition of a robot can be highly varied – an overview.

Read more on page 41

Connect

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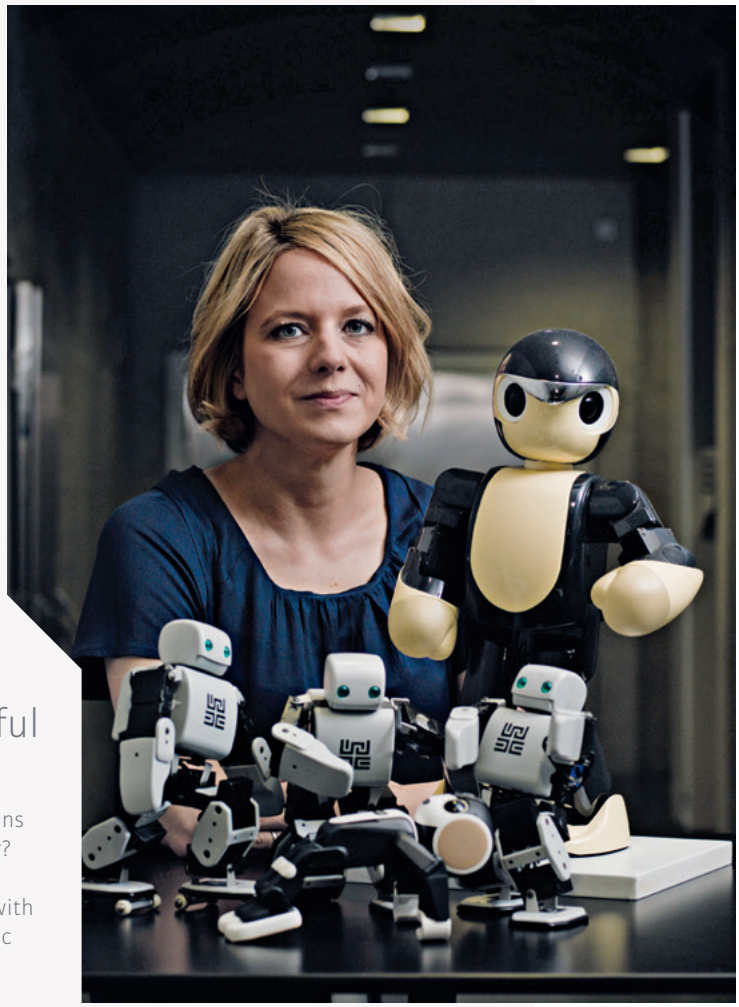
All about the people and ideas behind the new technologies



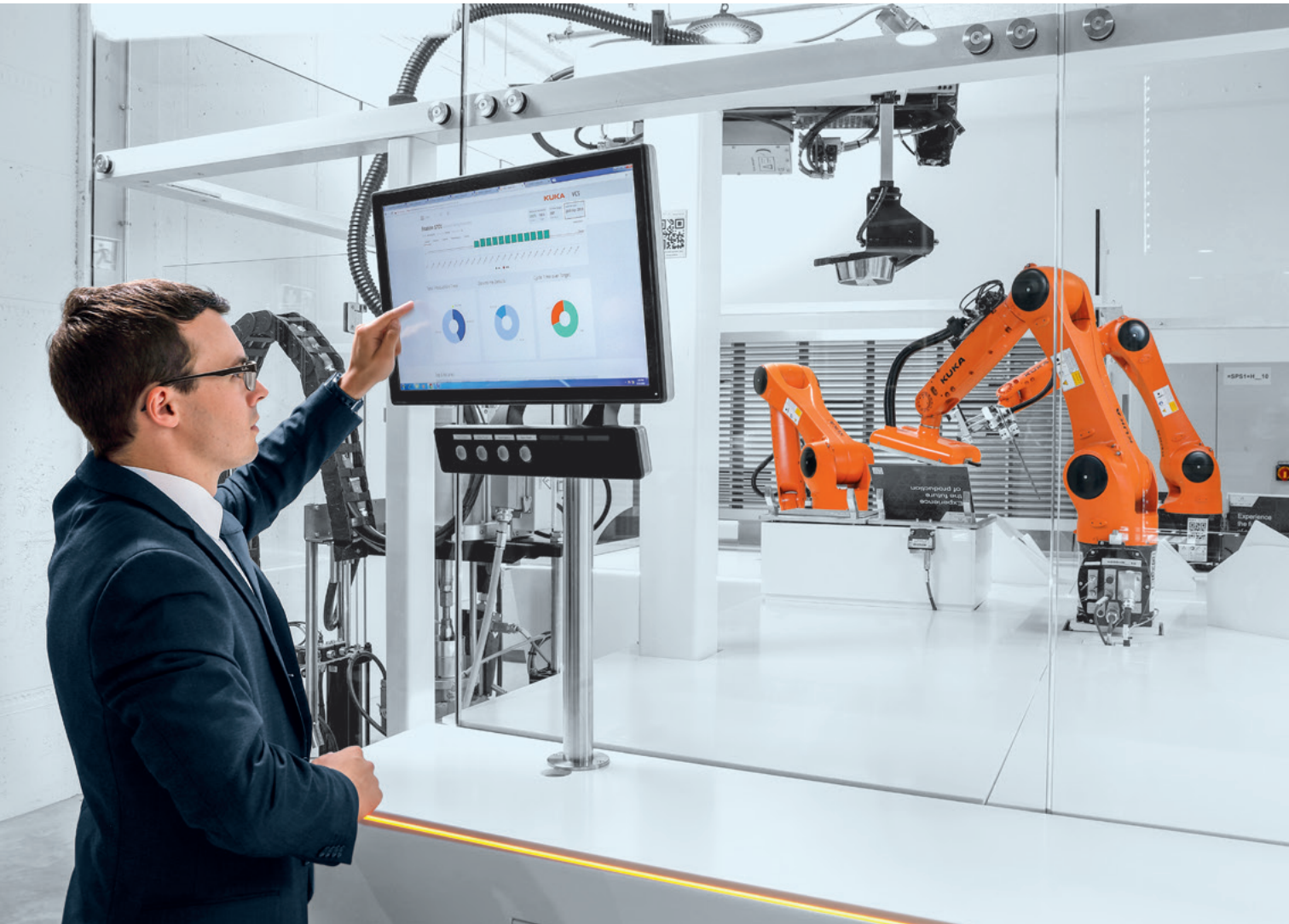
Humans and robots – a successful team?

Under what conditions can humans and machines work well together? And when will robotic colleagues truly be accepted? An interview with Martina Mara, professor of robotic psychology.

Read more on page 38

»The potential to revolutionize production processes«

More flexible, faster, more versatile: the demands on products have changed. The versatility of a production system is an important criterion for the long-term viability of a manufacturing company. From a technological perspective, this is highly complex and involves great risks – and results in unusual partnerships. Interview with Leonhard Forster, Head of IoT at Munich Re, and Robert Kamischke, Director of Digital Services at KUKA.



Leonhard Forster, Head of IoT at Munich Re

In the 'Smart Factory as a Service' project, an automation company, a reinsurer and a consultancy are working together – at first glance these are three very different fields. How do they fit together?

Leonhard Forster: Very well. In this cooperative venture, three market leaders with complementary capabilities and different perspectives have teamed together. Munich Re, KUKA and MHP are working together on a model factory to test flexible production possibilities. This also involves the use of AI-based technologies. The automated production facility is developed by KUKA, while MHP advises as a digitization expert using the 'closed-loop manufacturing' approach – an all-in-one manufacturing method – and ensures system integration. Munich Re completes the business model with risk management and financing models.

Will we see more such partnerships in the future – have business concepts changed?

Forster: Digital transformation requires high flexibility and transparency along the entire value chain. Customer expectations have changed, with manufacturers having to respond quickly to market requirements. That results in high capital costs and involves substantial uncertainties; we need new approaches in order to remain competitive. At the same time, IoT applications have to offer clear added value. This will only work if customers actually perceive an improvement.

Robert Kamischke, Director of Digital Services at KUKA

There is currently much discussion about the added value of Industrie 4.0. What exactly does this mean for everyday production?

Robert Kamischke: We are focusing on a new model that has the potential to revolutionize the production processes of the future. SmartFactory as a Service (SFaaS) is intended to produce different product types in any batch size independently and flexibly, thereby meeting customer requirements with regard to individualized products. If this works, SFaaS will reduce the market launch time for new products by up to 30 percent, for example, and thus improve key competitiveness indicators for manufacturing companies.

For what branches of industry would this be suitable?

Kamischke: The aim, in automotive manufacturing for example, is to break up rigid production chains and replace them with flexible concepts. The field of electromobility is a good example of why this is necessary: current technology is undergoing rapid further development, resulting in a constant need for new systems and manufacturing methods. This not only concerns the production capacities for batteries, the structure of the vehicle itself is also changing, especially the underbody. As long as parallel concepts such as cars with internal combustion engines, hybrids and electric vehicles are built on the same line, particular flexibility is required in order to ensure that market developments can be addressed accordingly.

This is what intelligent production can look like

Customers face the challenge of reacting quickly and flexibly to market requirements. SmartFactory as a Service can do this – it serves as a model to advance completely new concepts in an environment of real production systems. In Munich, customers can visit this model factory in which an individual puzzle is manufactured by way of example. Upon completion, it is deposited in a buffer store. The customer can pick up the puzzle here.

Transport robot

The puzzle passes through all of the production steps fully automatically in less than 15 minutes: the materials are fetched from the container, the image is printed, the puzzle pieces are cut by a laser, the image is glued onto a folder and the product is supplied via a buffer store and repository. The customers can view the status of their puzzle at any time and are notified when the puzzle is complete.

Pick-up station

Risk management and financing models

Customers are advised on the possibilities offered by Industrie 4.0 in everyday production and how risks can be minimized.

SynQ

One key element is 'Synchronized Intelligence'. It controls and monitors all logistical work steps. SynQ makes use of an interface to communicate with the system components and also communicates with each customer by e-mail. The software creates replenishment orders, arranges the delivery of materials and produces statistics for all of the automated processes.

Printing process

The puzzle motif is printed in high resolution onto the cardboard.

CO_2 laser cutting

The puzzle is cut into its separate pieces by a laser. The laser beam vaporizes the material on hitting it. This results in precise cuts.

Input terminal

Here, the customer starts the order process. The customer's own image can be uploaded or a standard image can be selected. Customers are then able to determine the shape of the puzzle pieces and place the order.

Bonding process

The puzzle is glued into a folder.

KUKA SmartProduction_monitoring

All robots, cells and logistics of the Smart Factory are digitally networked. Thanks to the standardized user interface of SmartProduction_monitoring, it is possible to observe and analyze their status and detect any potential malfunctions or imminent failures in good time. In day-to-day production, this enables an increase in total system availability and a significant reduction in costs by minimizing downtimes.

Closed-loop manufacturing

Digitization experts advise throughout the project phase and ensure full system integration.

»The robot should be a likeable tool«

Martina Mara is Professor of Robotic Psychology at the Johannes Kepler University in Linz, Austria. She deals with questions of how robots are perceived and under what conditions people enjoy working with robots and use them effectively. In this interview, she outlines what tasks robots could assume in the foreseeable future, how people's apprehension regarding mechanical assistants can be allayed and in which cases robotic 'colleagues' are regarded as troublesome.

How long will it be before such sophisticated robots as the famous C-3PO from the 'Star Wars' films will be assisting us in our everyday lives?

Prof. Martina Mara: (Laughs) 'When?' is always a difficult question to answer. In hindsight, everyone is almost always wrong! It will certainly still be a very long time, however, before robots have the properties of the neurotic C-3PO. There might never be such robots. In current research, there are no signs indicating that machines with consciousness or real emotions could ever be manufactured. It is, of course, possible to simulate these things though. There are many applications in which robots imitate human-like behavior. This naturally has an effect on people.

Where are the limits of robotics?

Mara: It is virtually impossible to teach robots human capabilities such as empathic communication, creativity when dealing with new concepts, or irony. It is also difficult to imitate various motor skills. Walking upright along a busy shopping street, for example, or the dexterity involved in handling different materials such as glass or paper. However, robots have their strengths in many other areas. Besides, there is no real need to replicate what humans can already do very well.

"In the medium term, we need to ask ourselves the following question: what do we actually want to automate?"

There is currently much discussion about how robots could provide humans with household assistance, for example. What potential applications do you see for service robotics?

Mara: In the short term, I see further development of cleaning and lawn-mowing robots and also simple social robots for household use that, when requested, can take photos, play games or search for information on the web, for example. Essentially, an advanced form of voice-controlled systems. Furthermore, there is certainly potential for mobile transport robots that can fetch objects or possibly even deliver packages.

And in the medium term?

Mara: In the medium term, we need to ask ourselves the following question: what do we actually want to automate? What should humans do and what tasks should be taken over by robots? It can make sense to transfer tasks to robots and artificial intelligence so that we have more time for other things. We benefit most when robots collaborate with us on a complementary basis.

Humans and robots collaborating directly. Can that work out well?

Mara: We know that people often respond skeptically to robots if their appearance or behavior becomes too human-like. That triggers unease. While this is not generally a problem in the case of collaborative robots in the workplace, more should nevertheless be done here to address the different needs of different people. The requirements of an expert differ from those of an untrained layman. One person might prefer a more active interaction partner, while another might get along better with a more restrained robot that does not present the next workpiece until the user has issued a command. Custom-tailored robot behavior that can adapt to these different needs may become possible in the future.

Can you provide an example of the sensible use of service robotics?

Mara: In my opinion, it makes little sense entrusting robots with the social/emotional supervision of children or the elderly. Instead, they could provide mechanical assistance in patient care, for example. I am thinking of mobile platforms that could transport bed linens or even a robotic exoskeleton that could be worn by caregivers to support their backs when lifting. The robot could save staff

time and relieve their physical burden. It would not be a rival, but – ideally – a likeable tool.

What challenges does this still entail?

Mara: In the future, more and more people who are not robot experts will have encounters with robots. For this reason, the technology needs to be optimized, for example with regard to the fluency of communication. Currently, this is often still sluggish, which can lead to uncertainties in interaction. It is not always clear whether the robot has already completely executed a task or whether it is still waiting for input. We know from tests that humans tend to terminate the cooperation quickly in such cases. Robots must therefore become faster and their states and targets must become easier to understand.

A personal question, if we may: do you use service robots yourself?

Mara: I would like to have a window-cleaning robot (laughs). All joking aside, I often test various prototypes, but am still waiting for the ultimate solution.

What exactly is a robot?

From chat bots that act as smart assistants and answer questions online to intelligent industrial machines that perform monotonous and hazardous tasks: today, we encounter smart helpers in many areas of life and in different forms – both hardware and software.

A guideline of the Association of German Engineers (VDI) defines industrial robots as "universally applicable manipulators with several axes, whose movements are freely programmable (i.e. without mechanical intervention and allowing modification) with regard to sequence, paths or angles, and can be assisted by sensors if necessary. They can be equipped with grippers, tools or other manufacturing equipment and can perform handling and/or other manufacturing tasks." From autonomous service robots as domestic cleaners to medical robots that assist physicians in operating rooms – not forgetting humanoid toy robots for the engineers of tomorrow: the range of potential applications is diverse – and is by no means limited to use in factories.

The term 'robot' is also encountered in the field of software – usually abbreviated to 'bot'. The Competence Center Public IT defines bots as "computer programs written by humans that, depending on the specific objective, can independently gather data, disseminate information, and communicate and interact with other users." The nature of bots is varied: as artificial users of social networks, bots are meanwhile capable of imitating human behavior highly convincingly and manipulating political discussions, for example. They can also be very helpful, however, such as chat bots that access databases of answers and are used on websites when users require help.

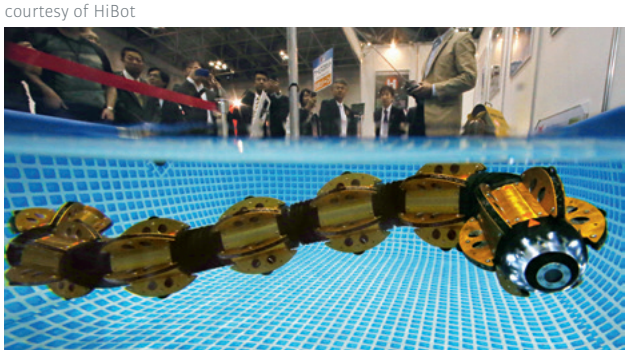
Robotics in a different perspective

Even outside the halls of industry, robots amaze us with their diverse application potential. Here, we present mechanical helpers in unusual situations.

A charging assistant for e-mobility

Broad acceptance of e-mobility necessitates a comprehensive charging infrastructure with fast and user-friendly charging opportunities. In a joint research project, KUKA and Volkswagen are combining decades of robotics and automation experience with automotive and service expertise. The charging assistant takes care of handling and positioning, automatically connecting the charging cable to the parked car.

courtesy of HiBot



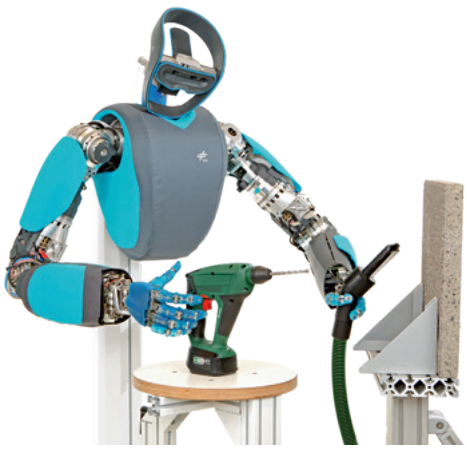
Amphibious robot ACM-R5H

The ACM-R5H is an amphibious robot that imitates the movement of a snake. With its closed housing and 3D motion capability, it can move over uneven terrain, dive underwater and swim back to the surface. The range of potential applications includes inspection of ships' hulls, submerged pipelines, flooded confined spaces and the monitoring of ports and coastal areas.

AnyMAL – the Robo-dog

Robo-dog AnyMAL moves autonomously in difficult terrain, such as sewerage systems or offshore platforms. With its four legs, the robot can crawl, run, jump, climb or carry. AnyMAL can be used both indoors and outdoors for inspection and manipulation tasks, in natural terrain or fields of rubble for search and rescue tasks, or even on stage as an entertainer.

Anybotics



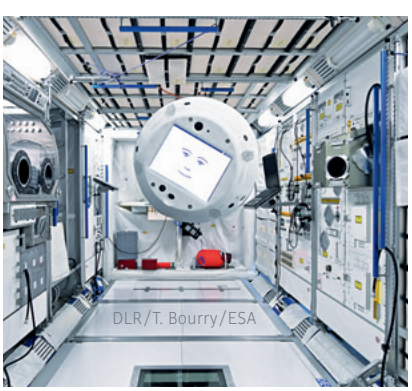
Sebastian Wolf, DLR CC-BY-ND 3.0

Research robot David

The anthropomorphic robot David is a research robot from the German Aerospace Center. One objective of the development is to approximate human capabilities, particularly in terms of dynamic performance, dexterity and resilience. David is not only comparable in size to a human, but also has a similar range of motion. All finger joints can be controlled separately, endowing the system with an exceptionally high degree of manual dexterity.

Swapping the factory floor for a roller coaster

KUKA Coaster is a robot with a seat mounted on its arm in place of tooling. As an amusement ride, the Robocoaster provides an adrenalin kick in amusement parks – at different speeds according to preference and level of courage.



DLR/T. Bourry/ESA

CIMON

The CIMON robot (Crew Interactive Mobile Companion) has been developed to support the work of an astronaut and at the same time to boost his efficiency. On its screen, it can display and explain information and instructions for scientific experiments and repairs. Speech-controlled access means that the astronaut has both hands free for his work. CIMON can move through space, see, speak and hear. It cannot learn independently, however. It has to be actively trained by a human to expand its capabilities. CIMON is currently in operation on the International Space Station (ISS).

»Added value through machine learning«

Problem solver or dangerous technology? There is currently much hype about artificial intelligence (AI). Prof. Torsten Kröger is Head of the Institute for Anthropomatics and Robotics at the Karlsruhe Institute of Technology and is a visiting researcher at Stanford University. He was previously responsible for the field of robot software at Google's parent company Alphabet. In this conversation, the AI expert explains why many fears are unfounded and what rules the new technology needs.

How much of the current debate about artificial intelligence is mere scaremongering and how much is real?

Prof. Torsten Kröger: Our understanding of artificial intelligence has changed repeatedly over the years. In the 1990s, for example, the focus was on chess computers; today personal assistants such as Siri and Alexa are in the spotlight. Rationally speaking, there is no well-defined literary or scientific definition of artificial intelligence. Certain aspects of artificial intelligence are well-defined, however, such as the term 'machine learning'. This refers to software algorithms that learn from data. In order to establish initial expectations for robotics, it is useful to make a distinction between the perceptual and motor capabilities of robots. The former create added value by enabling robots and technical systems in general to develop a semantic understanding of their environment. For example, they can interpret what is shown in an image or video. In robotics, capabilities related to visual and acoustic perception and detection are an important component of many applications. New possibilities will be opened up here in the near future. In the area of motor capabilities, much research activity will be required in the coming years, as it is considerably more expensive here – compared with perceptual skills – to generate good data for training purposes. Computers will thus not achieve superintelligence – not least because the systems are only designed for a single specific application. It is not possible to get even close to attaining the adaptability of a human.

To what extent will artificial intelligence change production in the future?

Kröger: In the near future, perceptual capabilities will play a more important role in robotics through their integration into existing cloud programming interfaces. Moreover, machine learning can be used as a universal optimization process for robots that have already been programmed. The long-term objective is for robots to learn independently. The robot is shown a task by means of language, image

> In the context of robot ethics, it is necessary to ask what is good and what is bad for humanity.

or demonstration, and should then be able to teach itself the task and perform it. We are still many years away from practical operation, however.

To what extent is robot ethics important in the context of artificial intelligence?

Kröger: Robot ethics is an important aspect. In this context, it is necessary to ask what is good and what is bad for humanity. Various different dimensions come into play here. One example is military applications. It must be clearly defined what is permissible and what is not. Furthermore, the effects of AI on society and on democracy must be observed. Major IT companies should not have any influence over election results. However, the very way in which data are handled must be questioned. Individualized film and product recommendations from Netflix and Amazon, for example, are already causing people to start living in private 'bubbles' of their own. Ultimately, ethics commissions will have to decide at a regulatory level how to deal with these issues, particularly societal ones.

What is our standing compared with other European countries/USA/China?

Kröger: Germany is in a very good position in Europe. Compared with the United States and China, however, Europe runs the risk of being left behind. Salaries that are paid in America, for example, are utopian in Germany and Europe. This is resulting in a significant brain drain. It is also important to consider, however, what we have to offer from a cultural and non-material perspective.

Did you know?

The word 'robot' is derived from the Slavic word 'robota'. It basically means 'enforced labor'. The Czech author Karel Čapek used the word in 1921 for a play in which artificial people, so-called robots, perform all arduous tasks.

Any questions?

Write to us!
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KUKA

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