

the o.i.

Robotics and I

Intelligent, intuitive, innovative: how new technologies are becoming part of our everyday lives.



Snapshot 4.0

Taking stock with a co-initiator of Industrie 4.0

Artificial intelligence

Man and machine in new harmony? A debate.

Young mavericks ...

... are shaping the future. Fresh ideas for the world of tomorrow.

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EDITORIAL



Dear Readers,

KUKA has evolved, transformed and re-defined itself. From a former robot and system builder to an automation specialist. From a process expert to a driving force behind Industrie 4.0. From a globally active company to a global enterprise. From 7,000 employees to 14,000 KUKAns worldwide.

KUKA is a company that draws on its 120-year history, tradition and experience, yet with a visionary look towards the future. A company that never shies away from adapting to changing times, indeed even shapes them.

Change has always been afoot at varying paces, but never at the current speed. IT integration is catapulting our company into a torrent of innovation, which is also carrying others along. Artificial intelligence gives rise to new possibilities in this context. The effects of these developments are multi-faceted, interpreted in various ways and vehemently debated.

We frequently participate in these discussions, taking on an explaining role. Our goal? To dismantle preconceptions and reservations in order to boost innovation – to the benefit of people. We are convinced of that.

“The o.i.” is a new magazine that not only expresses our way of thinking and our stance, but one that will also take our readers beyond the boundaries of the company. These developments are far too important for us to interpret by ourselves.

In this new journal, we aim to unveil the changing environment in which we operate, while including outside opinions and discussions. But first and foremost, we offer insights into a world which, once entered, is as fascinating as the technologies that we are occupied with.

We take our readers on a journey into the world of automation and digitization, with the robot as one of the most fascinating elements. It is gradually migrating from the industrial environment to our everyday lives and assisting us progressively. In this issue, we want to take a look at our digital future together with you.

We hope you enjoy reading it.

Sincerely,



One room and endless possibilities
for man and machine – thanks to
mobile robotics



IT'S TIME TO GET MOBILE

Predefined paths and inflexible processes: in the factories of the future, those days will be long gone. Mobile units are moving into production halls. After all, a production system can only respond quickly to changes if it is flexible. And this is exactly what it comes down to. We never lose sight of our goal to enable extremely versatile production on an industrial scale with the aid of mobility. Because, at the end of the day, customers are looking for individuality.



Want your favorite granola without raisins? That has been possible for a long time. Want to wait while your shoes are made for you right before your eyes just the way you want them? It won't be long before that's possible. What about a green car with sports seats, red stitching, patterned interior trim and an electric motor? The demand for customized products is even having an impact on large production lines in the automotive industry. "If I needed to adapt a car production line to accommodate a new model right now, it would take weeks. Mobility and modular production make it possible to reconfigure things in a matter of minutes," says the German computer and robotics scientist Prof. Dr. Wolfram Burgard.

The so-called matrix body shop concept of KUKA is one example of this. A production hall featuring the matrix concept is characterized by individual robotic cells. They are interlinked using freely programmable

logistics for the components to be manufactured. Each cell can be freely configured. Automotive components are transported to and fro between the cells on unmanned carriers known as Automated Guided Vehicles (AGVs) in order to undergo machining. A clear distinction is made between transport and manufacturing tasks. This paves the way for shorter product cycles and diversified product portfolios. "If I decide to incorporate mobility into my production hall, I will need far less space, I will cut costs and, above all else, I will be far more flexible," says Burgard, summarizing the benefits of mobility. The scientist heads up the research group for Autonomous Intelligent Systems at the Albert-Ludwig University in Freiburg, Germany.

These developments require a radical new way of thinking. If you enter "quick and flexible" on a search engine, you may well find this autocompleted to "quick response and >



Equipment that is permanently anchored to the shop floor will progressively disappear from production operations.

flexible manufacturing”. It is clear that “quick and flexible” are key attributes of tomorrow’s production systems. The issues that have been on people’s minds for years are now taking shape in the workshop. In its article on intelligent factories, the German government regards it as decisive for success that it is no more costly to make an individual product, for example a personalized red case containing a USB stick, than the same piece time and again by way of serial production. “The costs caused by all aspects of the process must be kept as low as possible. The competitive pressure is enormous. You need effective solutions in order to keep pace. Ultimately, you want the flexibility of manual production and the effectiveness of robot-based production. Imagine a situation in which two components are screwed together while they are being transported from one work station to the next. That saves a huge amount of time. And you need mobility to achieve it,” says Burgard, explaining the correlations.

Mobile robot systems that do not simply transport workpieces but also process them, while allowing direct collaboration with humans at the same time, will therefore be an integral part of the versatile, flexible factory of the future. Mobile units will equip robots with other tools in passing, quickly enabling them to carry out new tasks or process other workpieces.

One of the industries that will benefit most from mobility is the logistics sector. “Mobility is one of the determinant factors for success in this industry. Quite simply because products constantly have to be fetched from racks throughout these huge halls and brought to packing stations.” Mobility expert Dominik Jäkle from the Switzerland-based automation company Swisslog says: “We can achieve a great deal in logistics using mobile solutions. Equipment that is permanently anchored to the floor of production shops will become a thing of the past. On the contrary, we need elements that can be set up quickly and

easily and also moved to another part of the production process from one day to the next. Add to that the fact that manufacturing sequences can be expanded effortlessly in this manner, and entire systems can be relocated much more efficiently.”

One thing is certain: a conveyor that is anchored to the floor operates extremely reliably and is highly productive. However, it is also extremely inflexible. Such equipment will nevertheless not disappear from industrial halls entirely. At the same time, mobile platforms will find their way into production processes so as to meet the needs of each individual customer in a quick and flexible manner.



Mobile, autonomous units will be more and more common in production halls.





3 QUESTIONS TO

Christoph Bick

Head of R&D Mobile Robotics Operations at KUKA

- > First and foremost, mobility means flexibility in my opinion. Assembly line production can still be found in many modern-day factories. However, this type of production always means that the process is tied to a fixed line. Changing the sequence on a flexible basis is not possible. For this reason, conveyors will be replaced by mobile platforms to an ever increasing extent.
- > I actually see mobility as the icing on the cake. Implementing Industrie 4.0 in a mobile environment is a huge challenge because the planning, particularly with regard to infrastructure, needs to be very well thought out in advance due to the absence of the predetermined path and the comparatively simple installation of the assembly line. On the other hand, Industrie 4.0, with its tracking facilities, data evaluation and real-time analyses, brings greater added value in terms of predictive maintenance and the optimization of process workflows. Mobility makes it possible to lower unit costs. A modular production system provides the scope to leave out or add in certain machining steps, in line with the current requirements. Costly conversions are no longer necessary and the timing of process sequences can be optimized. Mobility is quite simply indispensable in cases where the component to be processed is extremely large, for example the fuselage of an aircraft. Because the fuselage cannot easily be moved from A to B, the robot comes to the fuselage. In such cases, mobile platforms are the be-all and end-all. A conveyor or a linear axis is too inflexible, impedes the production process and is therefore utterly unsuitable.
- > Yes, in my opinion they go hand in hand. The product diversity that comes as a result of customization gives rise to a complex production environment. There are two ways to manufacture products efficiently in a setting like this: either the product is placed on a mobile platform and is transported to those stations where work steps need to be performed, or a robot is installed on a mobile platform which moves it to the product or component.

What does mobility mean to you?

Do we need mobility in order to implement Industrie 4.0? What role will mobility play in tomorrow's production systems?

Mobility and new business models: is there a link between these two concepts?

YOUNG MAVERICKS ARE SHAPING THE FUTURE

Robots for people

For Dr. Martin Riedel the future begins with a pen and a sheet of paper. Whenever the inventor from KUKA Corporate Research comes across an everyday problem, creative ideas flash through his mind, begging to be written down right away. Riedel has already filed patent applications for more than 50 inventions on KUKA's behalf over the last 5 years and was recently honored with the Midea Technology Star Award, the sixth scientific accolade in recognition of his work. The kinematics engineer reveals, "I have been fascinated by motion technology for as long as I can think." He is convinced that humans and robots belong together. "The exciting thing is that we are often faced with entirely new challenges which we cannot address by simply improving existing solutions but rather have to develop totally new approaches," says Riedel. From the first sketch to the functional model, Riedel and his team realize their projects "with their own hands", as the team leader explains. Robots are not intended to replace any jobs, quite the contrary: their purpose is to serve human workers, assisting them wherever strenuous, monotonous or dangerous tasks have to be carried out. "We are improving the ergonomics and efficiency of logistics processes in supermarkets, for example, by using robots to help the employees fill the shelves with goods quickly and without straining their joints," he reports. The medical environment is another area where robots can aid humans, for instance robotic assistance platforms that

help elderly people to move about, thereby enhancing their independence in old age. Riedel and his team are also examining the question of how to design a robot system for more effective tumor treatment by radiation therapy while reducing the discomfort for the patient at the same time. If people are to interact with robots without ever having had anything to do with them before, an entirely new and intelligent interaction concept will be required, in which "robots are no longer operated but simply used," according to the inventor – so that robots can soon belong to people's everyday lives as a matter of course.



Dr. Martin Riedel, team leader at
KUKA Corporate Research





They are young, innovative and full of ideas for the future. How will we live, work and move about? What will our cities look like and how can we stay healthy? Bright minds from all over Germany give their views on what society could look like in the future.



Dr. Insa Thiele-Eich, climatologist

Climatologist reaches for the stars



Traveling to the stars and back. Dr. Insa Thiele-Eich aims to be the first woman to do so. It could all start in 2020. That is when the winner of the competition “Die Astronautin” (female astronaut) might be the first woman in Germany to travel to the International Space Station (ISS). As a climatologist, she is particularly looking forward to surveying our fragile planet from space. “I think the view of our planet and above all the relatively thin atmosphere from the space station is something special, leaving you with a strong

desire to protect the planet.” The desire for space travel is virtually innate to Thiele-Eich: her father Gerhard Thiele was also an astronaut. At the Russian military airbase Star City, Thiele-Eich has already completed her first parabolic flight and is currently undergoing tailored training with technical and scientific exercises. Part of the mission is to collect data regarding the impact of weightlessness on the female body and regarding psychological and social resilience. One thing is important to her: “One of my major objectives is to show that a lot has to change until we can forego the extra effort it takes to inspire girls and young women to work in technical fields. Ideally, society should simply be able to identify and promote the preferences and abilities of each and every child.”





Sina Trinkwalder, founder of Manomama



Social business in textiles

Sina Trinkwalder embodies a new type of entrepreneur: in Germany's first textile social enterprise, she employs people who are generally overlooked on the job market – and she is still profitable while doing so. As a result, she has been awarded the Order of Merit of the Federal Republic of Germany, among other recognitions. 140 seamstresses work at Manomama in Augsburg, producing cutting-edge fashion. Her company Bridgebag produces backpacks for the homeless that are so fashionable that they sell well even with normal customers. She is convinced, "Being socially responsible and having a profitable business are not mutually exclusive.

The economy is a part of society and we have to recognize that again. And the gains in terms of the humanistic aspects are priceless." With regard to marketing, Trinkwalder uses a mix of e-commerce, traditional direct selling and stationary (brick-and-mortar) retail. She firmly believes, "It is a fallacy to think that brick-and-mortar retailers have succumbed to e-commerce and the Internet." New concepts, courage and the will to network these two areas synergistically are needed. Trinkwalder's credo is, "The future belongs to entrepreneurs who act instinctively and with courage."

Technical healthcare assistants

Multifunctional robots autonomously moving patients from their rooms to the operating room, where they then act as assistants, is still pie in the sky – but Dr. Anja Werling and her colleagues at KUKA's Medical Robotics R&D department are working hard on intelligent assistants for doctors, nursing staff, patients and the elderly. Since her studies, the computer scientist has been fascinated by the opportunities offered by the digital world and how this has become part of our everyday lives. "Especially in healthcare, IT can play a role in helping people – and maybe even make the world a little better." For example through robotic assistance, as provided by the KUKA LBR Med lightweight robot: "Our LBR Med is becoming increasingly intelligent and already supports surgeons and neurologists in their work." At the moment, the LBR is learning how to cut bones cleanly under the guidance of a surgeon, so that artificial knees, for example, can be joined even more precisely to the patient. "Robots do not get tired, their hands never tremble, and they work with greater precision than humans, which makes them perfect assistants for surgeons," says Werling, who obtained a doctorate at the Karlsruhe Institute of Technology and attended the renowned Harvard Medical School as a visiting scientist. Neurosurgeons



Dr. Anja Werling, Medical Robotics Research & Development department at KUKA

can also rely on the LBR in the future when it comes to puncturing certain areas of the patient with ultra-fine needles. And that's not all. KUKA robots already help to position patients precisely during radiotherapy or to guide the beam source around the person at the ideal angle – if the patient moves, the robot senses the change with millimeter accuracy and readjusts its position accordingly. "The focus in the future will certainly be on intelligent and highly versatile robots. One day they will be a matter of course in facilitating everyday medical and nursing activities," Werling predicts.



The future of traffic



“The future will be here much quicker than we think,” says Steffen Braun, research engineer at the Fraunhofer Institute for Industrial Engineering (IAO) in Stuttgart. He is certain, his children will no longer have to get a driver’s license, as they will be traveling through

the cities in autonomous vehicles. Within the next ten years, robocabs might already be operating in cities. These are autonomous taxis that can be hailed to drive people from A to B. Braun is a co-initiator of the Morgenstadt Initiative, a research network dedicated to the city of the future. Cities could look entirely different if road traffic no longer took up five to ten percent of the overall surface area, as it does today. “Robocabs do not need parking space, as they are always on the move,” says Braun. Digitization is the driving factor behind the breakneck speed of progress to which city planners can merely react. Braun and his colleagues want to change that. “This is about much more than just traffic,” says Braun. Energy, construction, water, logistics – all areas are subject to this rapid change. Even the media will change, he believes. Because once we no longer have to sit behind the wheel ourselves, we will have much more time to read or watch videos.



Diplom-Ingenieur Steffen Braun, research engineer at the Fraunhofer Institute



In sync with the pulse of time thanks to artificial intelligence

Andreas Reinisch literally has his ear on the pulse of time. The co-founder of CSD Labs from Graz carries out research in the field of auscultation, the process of listening to body sounds with a stethoscope. With his eMurmur project he is breaking ground in the field of medicine for the future. “The software platform eMurmur ID is intended to introduce the current progress made in machine learning and artificial intelligence to the healthcare sector in order to provide patients with optimal medical care – doctors and algorithms working hand in hand,” is how Reinisch describes the project. The auscultation software that he and his colleagues have developed can hear heart murmurs even

in babies with such precision that it can accurately predict possible heart defects – much more precisely than would be possible with the human ear. The heart sounds are sent from an electronic stethoscope to a smartphone or tablet and analyzed by software. The doctor or a nurse receive a reliable diagnosis. “eMurmur not only assists doctors, but it also offers new opportunities for learning and teaching auscultation,” says Reinisch. <



Andreas Reinisch, co-founder of CSD Labs



“You can’t buy innovation”

“Valley of the future”, home of the “gifted, innovators and prophets” or “hot-house of innovation”. These characterizations of Silicon Valley certainly do not lack superlatives. But for good reason, because Silicon Valley on the US West Coast is considered the global mecca of the tech scene. Technology giants stand for American dominance in terms of start-ups and IT companies.



But what about Germany? Has Germany missed the boat internationally in terms of start-ups and high-tech? Konrad Peters, founder and CEO of Actiworks Application Solutions GmbH, feels this is not the case: “In Germany, people underestimate the significance of how ‘Made in Germany’ is valued abroad, whether it be cars or an Industrie 4.0 application.” Peters should know: the company he founded in 2011 while he was still a student is now an international player.

Actiworks Application Solutions develops apps that help companies track and optimize their processes from anywhere in the world. The company also deals with cloud solutions and is thus right at home in the world of Industrie 4.0. At the age of 30, Peters is one of those young entrepreneurs that one would expect to find in Silicon Valley rather than Germany.

Digitization is not waiting for Germany

So all is fine then? Not quite. “Digitization is not waiting for Germany,” Bitkom president Achim Berg warns. According to a study by the IT association, 60 percent of surveyed companies consider themselves latecomers with regard to IT. In 2016, only 20 percent of those companies invested in new digital business models. In terms of using state-of-the-art technology, German companies are only in twelfth place according to a current study by the World Economic Forum.



Dr. Eric Maiser, Head of the Future Business Competence Center at the German Engineering Association (VDMA), also takes a critical view of the reluctant approach to digitization. “Our industry needs to be proactive and flexible in order to develop some resilience to disruptive change. It is thus imperative to be open to new ideas. In Silicon Valley, disruption is viewed as an opportunity rather than a threat. We should learn to think like this.”

The lack of capital is another problem that affects entrepreneurs and start-ups in particular. While around 69 billion dollars in venture capital was invested in start-ups in the US in 2016 according to a study by KPMG, in Germany that figure was a mere 1.9 billion. “Funding of start-up companies is inadequate in Germany, and it is also based on the principle of indiscriminate all-round distribution. This creates the wrong incentives, which especially hurts small businesses,” says Dr. Stefan Schulz, CEO of Vincent Systems GmbH.

Founded in 2009, the company develops and produces innovative high-tech prostheses that are in great global demand. In 2017, Schulz and his colleagues were nominated for the German Future Award, the Federal President’s award for technology and innovation. It was not an easy feat to excel to that point. “The workload and the lack of financial security are brutal. Not many companies are cut out for this,” says Schulz.

Highly qualified employees are crucial

The lack of capital can, however, also have a positive effect: “Silicon Valley is flooded with capital. This makes companies lazy. In addition to that, German start-ups are not viewed as speculative investment opportunities which

are funded only to be sold for gain later on. We are creating sustainable value here.”

Of particular advantage are the well-educated employees. It is quite common for future colleagues to start at Vincent Systems GmbH as student trainees, write their thesis there and then start their professional lives. “We invest heavily in selecting and training our employees. They are our capital if we aim to remain technologically competitive. You can’t buy innovation, after all – it is produced by highly qualified colleagues.”

David Rhotert, founder and CEO of the crowd-investing platform Companisto, strikes a similar tone. “It’s a struggle here in terms of venture capital. But compared to the US, less money is being wasted in Germany. We optimize.” And this is exactly where Rhotert and his team come in with a view to promoting start-ups. “At Companisto, we focus on the seed to early stages, concentrating on technology. One of the main conditions we have for start-ups is that they are trailblazers in their field, and they must win us over with real innovations.”

One such example is myEnso, the online supermarket. The e-commerce start-up from Bremen radically puts the consumer at the center of its platform and aspires to reinvent retailing. “The fact that people in Germany have a critical disposition and offer a certain resistance can be a source of innovation given the right perspective. I think there are also a lot of cultural changes underway in Germany at the moment. If this is accompanied by courage to think outside the box and it is systematically implemented, then I look forward to the next big developments,” says founder and CEO Norbert Hegmann, >



thus flipping the preconception that Germany is afraid of anything new into an advantage. “Our company wouldn’t stand a chance in Silicon Valley. But in Germany, we can develop new business forms. Germany is the perfect seedling ground for that.”

Hidden champion even in the age of digitization

Compared to the big guys in the industry, myEnso is still small. As a matter of fact, the digital giants seem to have an unassailable lead. Politicians in Europe and Germany have recognized the challenges and are beginning to take countermeasures. For example, a regulatory framework is currently being developed to facilitate fair competition and to make it easier for smaller companies to enter the pan-European market.

According to Ilse Aigner, Bavaria’s Minister of Economics and Technology: “Bavaria is at the forefront in terms of Industrie 4.0. The mix of large corporations, a vibrant SME sector and the dynamic start-up scene provides the groundwork. But I do think that small and medium-sized companies need to catch up in terms of digitization.” Bavaria has adopted the “Bayern Digital” master plan and launched the “Zentrum Digitalisierung Bayern” (Bavarian Digitization Center).

The digitization potential of collaboration between agile start-ups and medium-sized enterprises is also pointed out by Dr. Maiser from the VDMA: “Nowhere else in the world will you find so many hidden champions that turn product ideas into tangible, affordable products. This is particularly the case for production engineering. At the same time, start-ups are very important: not only for new technologies, such as machine learning or artificial intelligence, but also for new ways of working and the joy of experimenting.”

Entrepreneur Konrad Peters explains what this may look like in practice: “We cannot keep up with the financial strength of Silicon Valley. And that is why, just like traditional industrial companies, start-ups look for niches where they can fully exploit their technological expertise.” Hidden Champions 2.0, so to speak. <

Robot Valley in Swabia

In the summer of 2017, KUKA announced extensive investments in its Augsburg headquarters. Around 100 million euro will be spent on expanding and modernizing the traditional location over the coming years. By 2025, a KUKA Campus is to be built step by step, an open and modern environment that promotes innovative ideas and provides a start-up atmosphere. “Innovation has made regions like California’s Silicon Valley world-famous. I think we can do the same,” says KUKA CEO Till Reuter. “Our vision is to create a “Robot Valley” or an “Automation Valley” here, because I think the economic region of Bavaria has what it takes.” The KUKA Campus combines production, research & development, training and innovation at a single location. The idea is to entice young entrepreneurs to the campus and to foster the start-up spirit in the region.



Electromobility in pole position

The automotive industry is undergoing the biggest transformation in its history. Megatrends such as digitization, autonomous driving and electromobility are determining developments – not only for manufacturers but also for suppliers.



Electromobility is on the threshold to the mass market. In Germany, sales of electric vehicles doubled last year, according to the industry association VDA. There are two main reasons for the development of alternative drive units: in the coming decades, the energy requirements of industrialized and emerging countries will continue to rise, while resources such as oil are becoming increasingly scarce. On top of that, automakers have been set climate policy targets to reduce CO₂ emissions.

“In light of these targets, it is paramount for the automotive industry to find suitable mass-market alternatives,” says Michael Kluger, Head of the Forum Electromobility e. V. “Electromobility is not a self-contained system. It must be viewed holistically together with issues such as power generation, infrastructure and automation.”

There are various alternative technologies to conventional combustion engines: hybrid vehicles that supplement the engine with an electric power unit, alternative fuels such as ethanol or hydrogen-powered fuel cell electric vehicles. The best-known technology, however, is battery-powered electric drive, which draws the required energy from energy storage devices such as lithium-ion batteries.

The advantage of battery electric cars is their efficiency, say their proponents. The batteries are getting cheaper, and the range of the vehicles is increasing at the same time. This has also been confirmed in a study by the consultancy firm McKinsey. It is an important factor because

the fear of being stranded with an empty battery is stunting electric vehicle sales. Furthermore, an increase in electromobility also entails a significant increase in electricity consumption.

But despite all the challenges, experts believe electromobility will be in pole position in the contest between the various technologies. It has the potential of becoming the new megatrend in the car sector and a key component of a smart urban lifestyle. Manufacturers have announced a wave of new electric cars for the coming years.

This also poses new challenges to suppliers. Because manufacturing battery cells and modules is very complex, and the technical processes are highly sophisticated. In order to produce batteries for electric cars economically, it takes automated, intelligent systems and experienced suppliers.

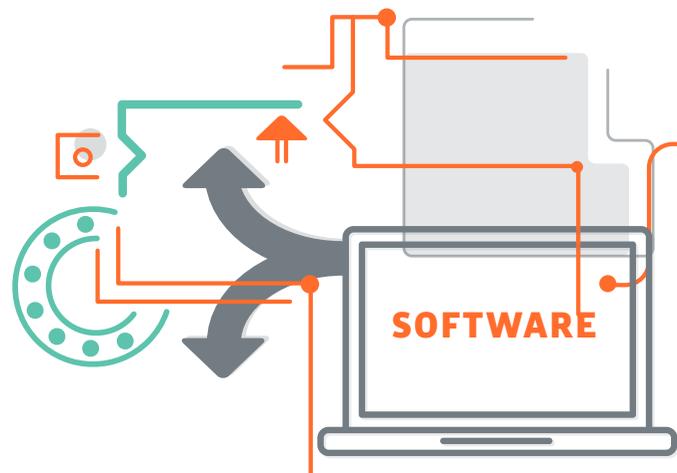
“To satisfy the increasing demand for electromobility, automakers are calling for quality and automated solutions in the production of battery modules,” says Dr. Joachim Döhner, expert for battery production at KUKA. “This makes close cooperation between engineering companies and the automotive industry absolutely imperative.” Automation and experienced suppliers can thus contribute to mastering the biggest transformation in the history of the automotive industry and bringing mobility into the future. <

Potential to become a new megatrend: electromobility



COLLABORATION IN THE ECO- SYSTEM

Be it self-designed sneakers, personalized children's books or one-of-a-kind vehicle equipment: customers want individuality. Very often they no longer wish to just consume, but rather to be involved in the creative process of developing the product they want. They are not prepared to accept higher costs, however: a custom-made product has to be manufactured at the price of a mass-produced item. This is quite a challenge for manufacturers – and for current business models.



Competition in the global market brings about increasingly high demands on quality, flexibility and personalization. Production has to be fast, flexible and adaptable, yet highly efficient. With a batch size of one, the traditional and proven value chain is pushed to the limit. “Business processes must be re-invented and re-designed. Networking is key for future business models,” says Dr. Christian Schlögel, Chief Digital Officer at KUKA. What is needed are flexible, networked and intelligent factories rather than rigid, linear production chains.

“Meeting these higher demands is only possible through increased cooperation among the participants, pursuant to the motto: think in terms of business models, act cooperatively,” Prof. Dr.-Ing. Thomas Bauernhansl, Head of the Fraunhofer Institute for Production Engineering and Automation IPA, explains. For successful solutions, it is important to merge the right set of competencies, open up boundaries between companies, and collaborate as partners within an ecosystem. “Machine builders who have been perfecting their mechanical or mechatronic products for decades have to work together with research and consulting partners in order to develop new digital services and business models, and to offer these through partnerships,” the director of the research institute adds. IT companies and start-ups are enriching the network with IoT skills.

Cooperating instead of competing

The open system has the advantage that individual partners can enlarge the solution database of the overall system with their unique know-how. Each company in the group contributes its own core competencies and integrates important partners, who add even more expertise to the network. Instead of engaging in competition, the participating companies benefit from the shared use of resources and competencies (cooperation). It's a win-win situation for all parties. This creates a value-creation network of hardware and software manufacturers, system integrators, research institutes and consultants, which can offer customers a wide range of production and logistics processes as well as optimization services.

For a manufacturer, data are the key to a system that can be controlled and analyzed at any time: products communicate what they are supposed to look like and where they are currently located, production machines communicate their processing status via data streams and request material or maintenance. These data volumes must be managed, read and analyzed. But that is easier said than done: a single production operation can entail numerous different machines, such as robots, welding guns, machine tools and conveyors. And these individual elements have many different standards for communication



protocols and interfaces. This is why a basis is needed on which the various data are collected – a platform.

For Daniel Reinhardt, Senior IoT Product Manager at connyun GmbH, this is the cornerstone of the ecosystem: “The ecosystem in itself is a complex construct that cannot be viewed purely from a technological perspective. The platform provides the technical framework for the different partners to collaborate in an organized manner.” According to Schlögel, the ecosystem lays the groundwork for learning together. “This allows us to bring innovations to market quicker and more broadly in a joint effort, making the platform more seminal through previously developed solutions.”

Success through trust and openness

In addition to the technical prerequisites, such an ecosystem places new soft requirements on the parties involved: the rules that apply to established business models must be extensively expanded, and the partners need to change their way of thinking. Openness, willingness to change and the ability to work together are critical for success. The big challenge for machine builders is to gain an understanding of value chains across company boundaries, and to open themselves to third parties, according to Bauernhansl. “Furthermore, legal and

technical framework conditions must be established that enable the members of ecosystems to pool their competencies and use them collaboratively in a way that the added value is more than just the sum of their individual contributions. This requires trust in their community and their partners.”

A value chain optimized in this manner saves resources and energy, while also potentially reducing goods flows and excess material. According to a study by Fraunhofer IPA, innovation and growth stemming from the development of Internet-capable products and corresponding business models will unlock an economic potential of 99.8 billion euro by 2025, an increase of 2.2 percent per year. Safety stocks along supply chains can be reduced by 30 to 40 percent, and the costs of complexity can even be reduced by as much as 60 to 70 percent due to increased transparency and reduced waste. Networked systems based on a business ecosystem make it possible to deliver the best product to the end customer: production can be flexibly converted and re-equipped to meet the requirements. So even a batch size of one can be economical – and value creation truly sustainable. <

Snapshot 4.0

The term Industrie 4.0 was first publicly mentioned in 2011, and it has shaped discussions about modern production around the world ever since. Seven years on, we take stock of the achievements and challenges of the fourth industrial revolution together with one of the initiators of Industrie 4.0, Prof. Henning Kagermann.

A According to the Industrie 4.0 Platform, about 15 million jobs depend directly or indirectly on the manufacturing industry; it is Germany's main job engine. But the requirements in production are changing. Versatile factories, intelligent robots and networked machinery are helping to meet this challenge. "In Industrie 4.0, production dovetails with state-of-the-art information and communication technology. The driving force behind this development is the rapid pace of digitization in business and society. It is transforming the methods of producing and working in Germany. After mechanization, electrification and automation, the second wave of digitization is now heralding the fourth industrial revolution," says Henning Kagermann.

Industrie 4.0 represents individualization and autonomy instead of standardization and automation.

But readying industry and production for the future is also a monumental social and societal task. Digitization is penetrating all areas of life and changing the way we learn and work. Many people are concerned that their jobs will be lost, or they have general trepidations about new technologies.

Acceptance is the key

"New technologies become accepted when individuals benefit from technology while being able to remain independent in interaction with it," says Kagermann. "The same is true for the digitization process." An example of this is e-government, where citizens benefit from online services and digital mail being offered by public authorities, replacing paperwork and long waiting times. E-government and the resulting personal gains can contribute to breaking down people's reservations about the digital world. Acceptance is the key to success for quick implementation of Industrie 4.0. And speed is more important than ever in the competitive global market, because this German initiative is attracting a lot of attention abroad.

The competition never rests

"We have a diverse economy in Germany, with strengths in many segments of industry and a reputation of excelling in building and mastering complex systems. Of course, we cannot afford to relax. There are many countries with visions and goals similar to ours," Kagermann explains. "Large-scale initiatives are evident throughout Asia, in particular. China, for example, has introduced its 'China 2025' program, modeled after Industrie 4.0.

The Japanese government has launched its 'Society 5.0' initiative and an 'Industrial Value Chain Initiative' with a focus on robotics. And in South Korea there is the 'Smart Factory Initiative' along with the more extensive 'Fourth Industrial Revolution' program: a combination of Industrie 4.0 and Smart Service World." An important factor for the success of future-oriented initiatives is a strong, homogeneous market, such as in China or the US. "If you have a homogeneous domestic market where you can become established, it's much easier to scale up further growth and set standards. Europe therefore needs a digital European single market in order to play a stronger role in the competitive global environment."

Germany still has a slight edge. Since 2011, a great deal has happened to spur innovation. This includes technology programs, model factories and initiatives such as the Industrie 4.0 Platform, which brings together politics, business and science. But other countries might soon surpass Germany, because we are lagging in two particular areas.

Digital infrastructure and digital education

"The expansion of broadband infrastructure is an area in which Germany has to catch up," criticizes Kagermann. According to the German Federal Agency for Civic Education, 38 percent of all companies in Germany with ten or more employees had an Internet connection with a data transfer rate of at least 30 Mbit/s in mid-2016. This puts Germany in the middle of the pack in Europe. Denmark is the frontrunner with 65 percent. If the digital infrastructure is not soon adapted to the requirements, Germany may miss the boat.

A professor of physics and former CEO of SAP AG, Henning Kagermann has been President of acatech (National Academy of Science and Engineering) since 2009. He is one of the most influential architects of Industrie 4.0 and was instrumental in coining the term. Henning Kagermann is a member of several committees and initiatives. He has been on the Supervisory Board of KUKA AG since 2017.



The success of Industrie 4.0 will also be decided in the field of education. “We have to prepare young people for a working world that is different from the environment we know today,” says Kagermann. “According to a survey of the popularity of STEM subjects among young people, conducted by acatech in 2017 (MINT Nachwuchsbarometer), a lack of state-of-the-art IT equipment in schools and insufficient training and professional development opportunities for teachers contribute to the fact that the development of education is lagging behind.”

Experts call for students to learn on a more individual basis with multimedia material. Online feedback can make it easier to update teaching aids quickly. This would allow students to work with multimedia material instead of decades-old books, and the imparted material could be tailored to each individual.

Lifelong learning – and a personal formula for success

A broad education over the course of their entire professional life allows employees to keep pace with technological developments and to find their place in tomorrow’s economy.

The jobs of the future will touch on many different facets, and interdisciplinary work will become increasingly important. What will

be the key competencies of Jobs 4.0? “Self-management, a good portion of flexibility and the ability to work in heterogeneous teams,” Henning Kagermann states confidently.

Critics say that industrial revolutions have been identified as such only in hindsight. But Industrie 4.0 is still in its infancy, and the course still has to be set in many respects. For this reason, some prefer the term ‘evolution’ over ‘revolution’. One thing is for sure: a gargantuan change is underway, and we have an opportunity to play an active role in shaping it. <

Henning Kagermann, President of acatech



We have to prepare young people for a working world that is different from the environment we know today.

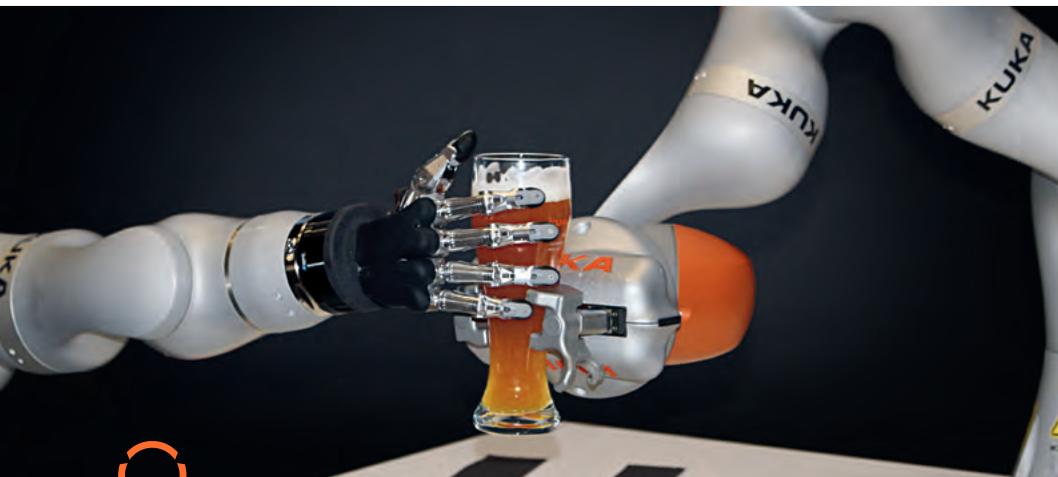
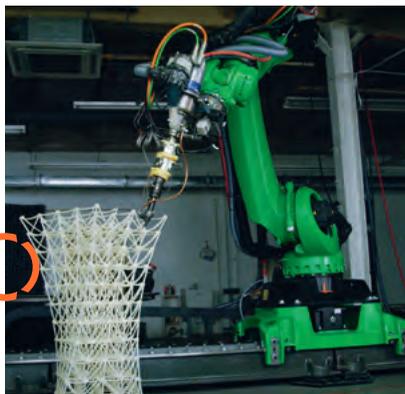
More than just industry and production

Robots and future technologies arouse amazement even outside factories. We have collected a few highlights.

High speed with an electric drive: KUKA is a partner of the ABT Schaeffler Audi Sport Formula E racing team.



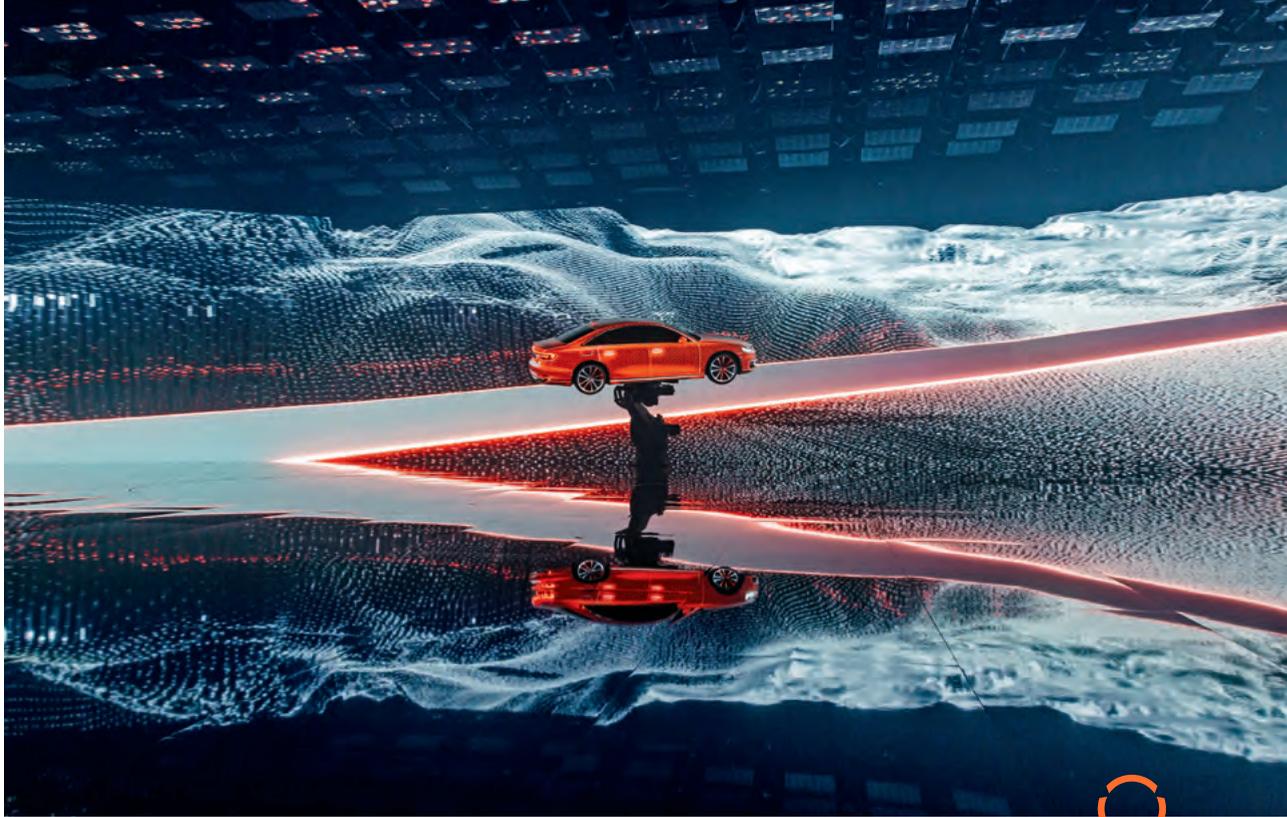
3D printing has the potential to revolutionize architecture. A robot provides support at this art installation in Nashville.



Sense and sensitivity: handling fragile wheat beer glasses is no problem for the sensitive LBR iiwa lightweight robot (here with a Schunk gripper).



Precision landing during the "Bottle Flip Challenge" in Texas: machine learning allows bottles to be thrown with pinpoint accuracy.



World premiere of the Audi A8 in Barcelona – with a robot impressively setting the stage



Custom-made product from the smart factory: German Chancellor Angela Merkel examines her individual puzzle at Hannover Messe.



Representatives from the world of politics, business and trade unions in a good mood – and with good reason: KUKA is investing 100 million euro in the Augsburg headquarters over the coming years.





Robotics for people

A COBOT FOR ME



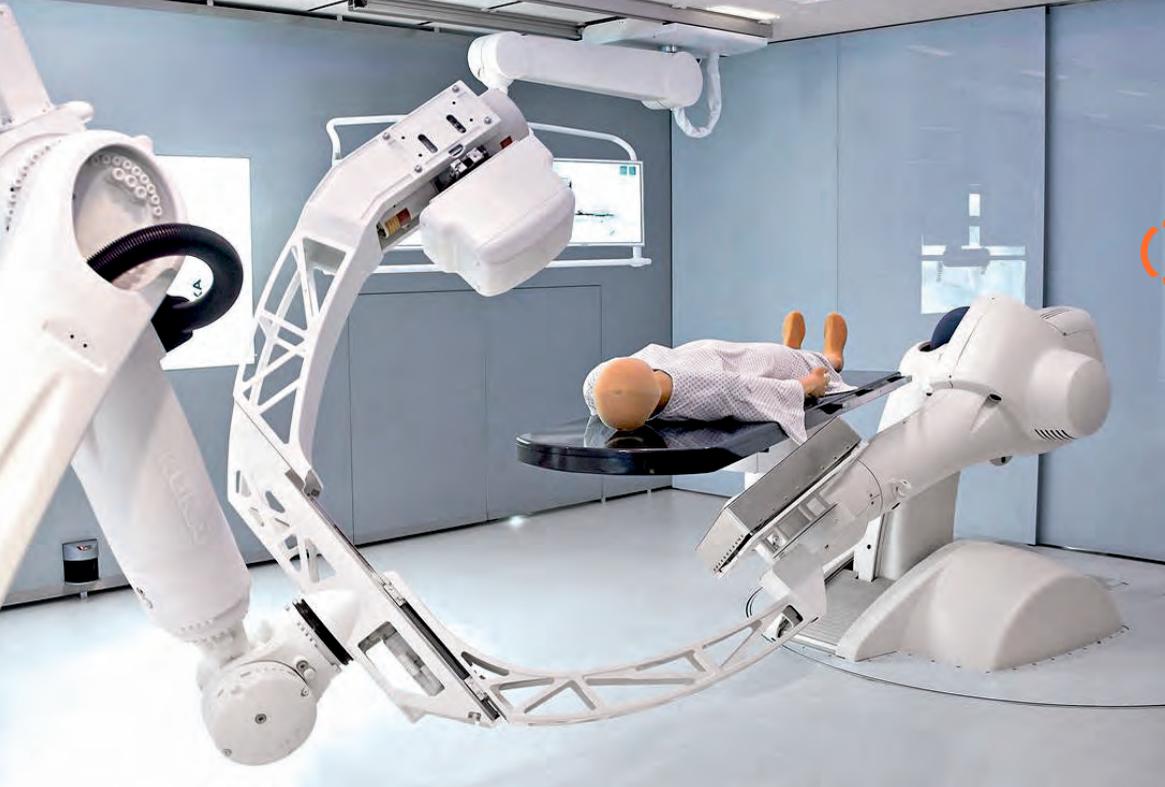
Until now, robots have been primarily used as heavy-duty industrial machines performing monotonous tasks behind factory fences. But the future belongs to a more flexible and intelligent generation: the sensitive robot assistant that offers support in everyday life. And we do badly need support in some areas.

D“Do you have a cellphone yet?” Only 15 years ago this question was generally answered with head shaking. Too expensive, too cumbersome, too few functions. As strange as this reaction may seem today, it is likely that one day we will look back in a similar fashion on the question: “Do you have a cobot yet?” At least that’s what Dr. Albrecht Hoene, R&D Director for Human-Robot Collaboration at KUKA, has in mind: “Sensitive robots that can directly interact with humans will play an important role. They will assist us in addressing the challenges of the future.”

The population of industrial nations such as Germany is becoming increasingly older. In Japan, Italy and Germany, for example, the percentage of people over the age of 65 is higher than 20 percent. And the forecasts predict a progressively aging population: while the world’s median age was 29.6 in 2015, the prediction for 2100 is already 49.2 years. What are the consequences of the life expectancy of newborns nearly doubling in the last hundred years while birth rates are going down at the same time?

The robot for humans

The demographic change is evident in the working world: the number of older people is rising and the number of young skilled workers is declining. Human-robot collaboration (HRC) is the key to coping with day-to-day work in the future. The idea is to merge the strengths of robots with the abilities of humans. “HRC makes it possible to >



Exact positioning of patients thanks to robotic assistance

ease the workload on people, thus keeping them on the job longer,” according to Hoene. Robot assistants are particularly useful for activities that are unpleasant, ergonomically unfavorable or monotonous. Such as in assembly, where robots can act as intelligent lifting aids. But we also need urgent support outside the working world. After all, we are getting older and more frail – the aging population is really putting healthcare to the test.

More efficient hospitals – more time for patients

“We are facing a global challenge in the healthcare sector,” says Stephan Sonderegger, CEO of Swisslog Healthcare. “All aspects of the industry are transitioning.” There are fewer and fewer specialists for ever more patients, while the statutory requirements are high. Hospitals have to reduce costs and operate more efficiently. This means shortening the patients’ stay while at the same time keeping the quality at a high level. Automation can provide logistical support, according to Sonderegger. A more efficient division of labor allows employees to focus fully on the patients, thus increasing the quality of care.

“Our solutions affect the entire medication supply chain.” Swisslog helps hospitals and healthcare facilities to make material transport and medication management more efficient. Drugs are stored, delivered and dispensed automatically. Drug management, which used to be very time-consuming and above all error-prone, is thus significantly improved. This ensures that every patient receives the right drug at the right dose.

Golden years at home instead of a retirement home

For many older people, living in a care facility is just as unavoidable and unpopular as staying in a hospital. People want to grow old in a familiar environment, even if

they are no longer in good physical shape. “Allowing people to stay in a familiar environment for longer, so-called home assisted living, will be an important issue in the future,” says Michael Otto, Vice President of Healthcare & Advanced Robotics at KUKA. Assistance systems can make it possible. They support care personnel and doctors, but also patients in their very own homes. For example, an intelligent mobile walker could help to prevent falls and assist people to get up and sit down. An additional navigation feature could also help people with dementia to live independently for longer.

But how high is the acceptance of robots? Unlike some industrial nations like Japan, where care robots are already lifting patients from their beds or where animal robots with furry covers cuddle with the residents, care robotics in Germany is still in its infancy. Michael Otto is optimistic: “The acceptance of assistance systems is growing – it is a matter of assistance, not replacement.

To spur development, technology partnerships are crucial especially in the care and rehab sectors. This type of partnership created, for example, ROBERT®, a robotic rehabilitation device that aids in the mobilization of bedridden patients. It assists physiotherapists in physically demanding and repetitive exercises.

Smaller surgical procedures, faster healing thanks to robot-assisted operations

Traditional medical robotics has made significant strides. Robot assistants are already being used successfully for tumor treatments, imaging or during operations. “Each and every day, our technology provides support for 1500 tumor and cancer treatments, 2000 cardiac catheterizations, and we are currently supporting more than

Sensitive robots are helping more and more people in their daily work.



120 clinical trials with our robotic equipment,” says Otto. The robotic surgical assistants help to make procedures minimally invasive – which means smaller wounds and faster healing.

In an article the Deutsches Ärzteblatt (German medical journal) took a look at the developments in robot-assisted surgery in 2016. “For most users, robot assistance ultimately provides minimally invasive surgery with the advantages of unrestricted access,” the Journal of the German Medical Association and the Association of Statutory Health Insurance Physicians wrote. “The camera additionally allows magnification of up to ten times with an absolutely steady image.” This also opens the door to new possibilities for complex interventions.

The costs for such a technology investment are offset by the advantages of faster and more precise operations. Which is not only to the benefit of patients’ health, but is also more efficient for the hospitals.

An indispensable assistant for our daily lives

Even outside of hospitals and working life we are likely to encounter cobots more frequently in the future. “Robots will support people in many day-to-day activities in the coming years. And autonomous driving will also be an integral aspect,” says Dr. Till Reuter, CEO of KUKA AG. In a strategic partnership with Volkswagen, KUKA is working on robot-based solutions for electrically powered and self-driving cars. For example, a sensitive, HRC-capable

robot independently connects one of VW’s electric vehicles to a charging station as part of the joint e-smart Connect research project. The car simply needs to be parked in a designated parking space, and everything else is handled by the mechanical assistant.

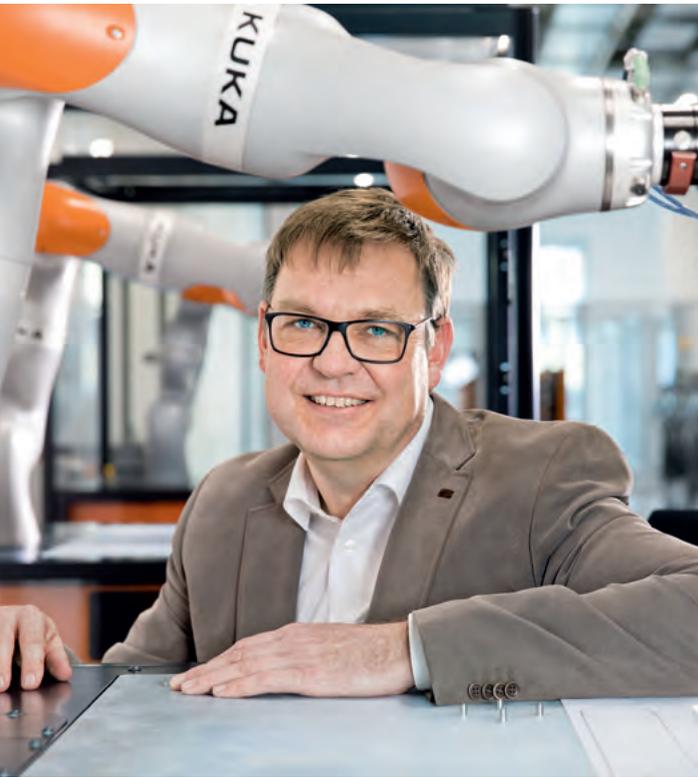
Robots are powerful and indefatigable, working precisely and reliably. They can relieve people of unpleasant or dangerous tasks and provide everyday help. The possibilities are endless, with ideas such as intelligent alarm systems, aids in cleaning dangerous substances, and even lifting assistants.

“I think we are out of the gate,” says Reuter about the future of robotics for end consumers. “The first cell-phones were only used to make calls. Today, smartphones are virtually everyone’s permanent life companion. I think we will see a similar development in robotics.”

And the question: “Do you have a cobot yet?” will probably no longer sound all that futuristic.



Joint project of KUKA and VW: the robot as an assistant for electric car drivers.



3 QUESTIONS TO

Dr. Albrecht Hoene

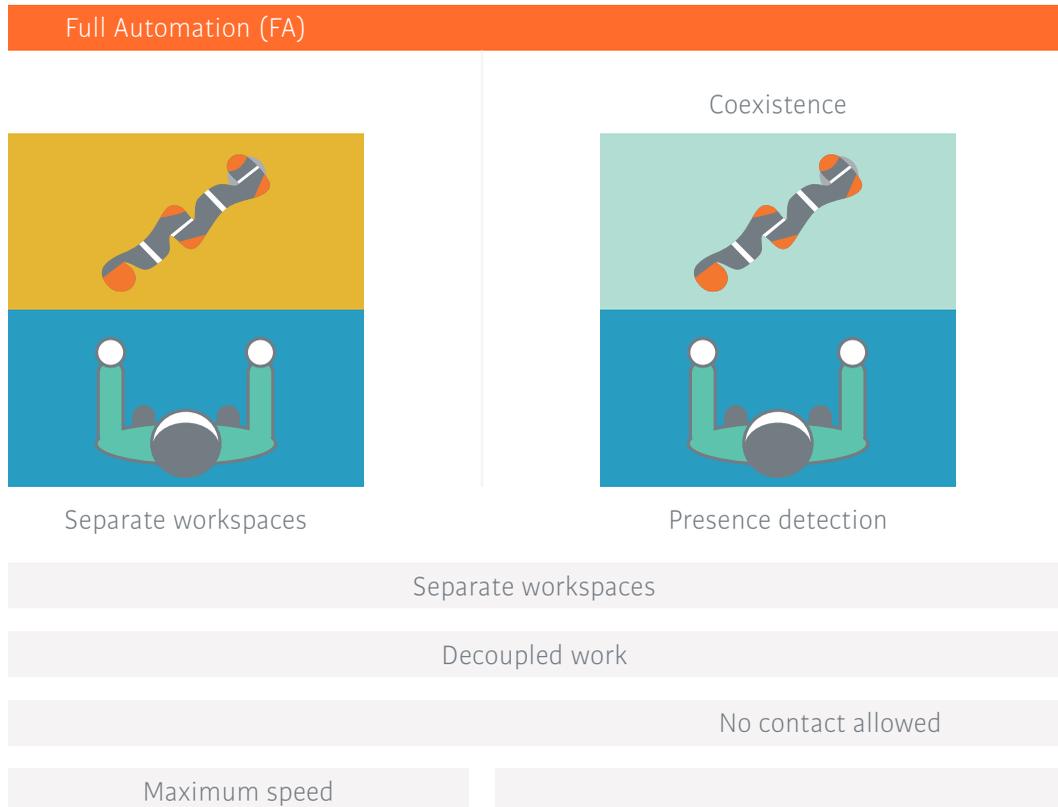
R&D Director for Human-Robot Collaboration at KUKA AG on the future of human-robot collaboration

The trend towards individualization certainly plays an important role: order quantities are decreasing while product diversity is increasing. Production must be capable of adapting extremely quickly. We need more flexibility and adaptability in the factory. In the past, we had only two ways of doing things: manual labor or full automation. HRC fills exactly the gap between the two: gradual, flexible automation of individual tasks. And HRC puts an end to the idea that automation is only worthwhile for high-volume production.

What are the benefits of HRC to industry?

Forms of human-robot interaction

Coexistence, cooperation, collaboration: there are various ways in which humans and robots can work together. Sensitive robots like the KUKA LBR iiwa allow collaboration in a shared workspace – and thus open up countless new possibilities.



In industry, the prime objective is to do away with safety fences. They are inflexible. Picture a robot cell that has material coming in and going out. If you want to automate this, you need safe and monitored access for the conveyor and transport systems. But it would be more elegant if the fence wasn't there in the first place. The goods are delivered, the robot picks up the material and work continues promptly. And if a person is in the vicinity, the system slows down and comes to a halt. This is how automation can make life easier.

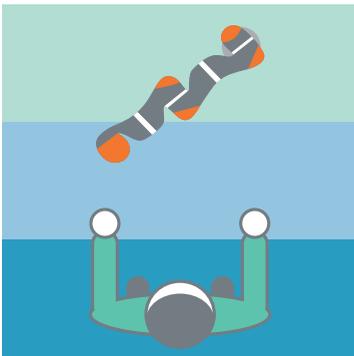
What is your vision for human-robot collaboration?

The future belongs to HRC, which will have an ever greater impact on industry. It will become increasingly important to make larger robots for heavier loads HRC-capable. There are some significant challenges here. Remote sensors and tool safeguarding can help to avoid collisions and to make entire factory halls operate flexibly.

What will HRC 2.0, in other words the human-robot collaboration of tomorrow, look like in factories?

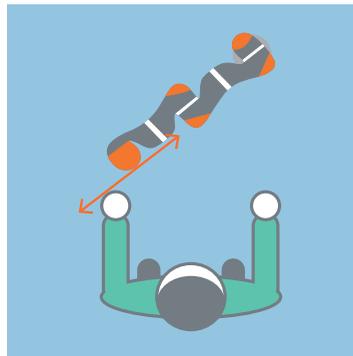
Human-Robot C... (HRC)

Cooperation



Intervention zones

Collaboration



Shared workspaces

Shared workspaces

Coupled work

Contact allowed

Adapted speed

Intuitive human-robot interaction
with a smartphone – a project at
KUKA Corporate Research



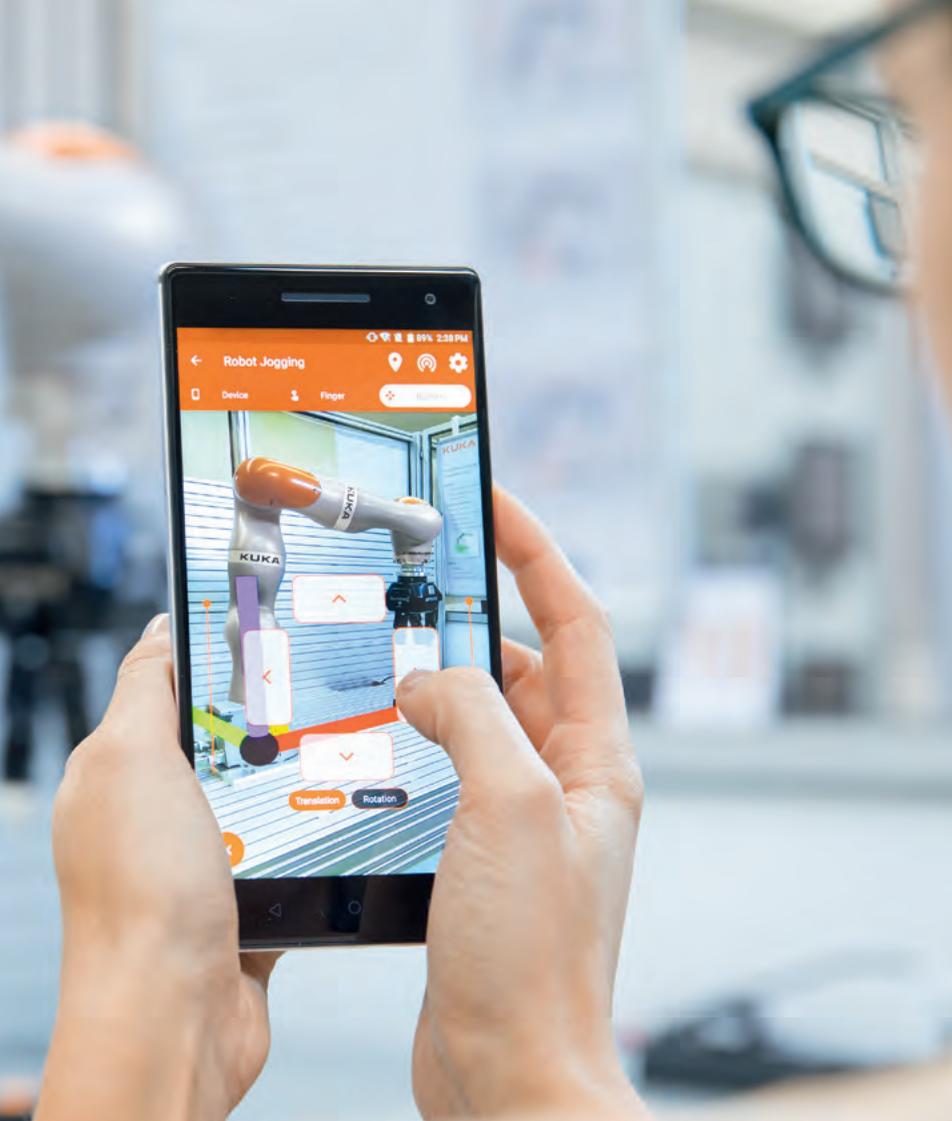
Robotics for everyone

FROM APPRENTICE TO JOURNEYMAN

The digital transformation is bringing forth intelligent products that make all of our lives easier. After all, who is willing to live without their smartphone in this day and age? Hardly anyone, according to the statistics portal Statista: 4.4 billion smartphone connections were registered in 2017, while the figure was only ten percent of that in 2010. The reason for this success is that smartphones fill our needs in a wonderfully simple fashion: they offer countless possibilities, yet are still easy to operate – a decisive factor in their momentous success. The industrial sector is striving to replicate this blueprint for success, bringing automation to a whole new level.

Increasingly simple control of robots is not an end in itself. According to the International Federation of Robotics (IFR), the number of industrial robots worldwide will rise by 14 percent annually until 2020, at which point it will surpass the three million mark. This increase and the need for production to be ever more flexible are the reasons why more and more people are coming into contact with robots. It will be quite a challenge to find enough qualified personnel to handle these machines.

Moreover, the product range in manufacturing is increasing as a result of automation, allowing companies to offer a wider selection. This also requires robots and intelligent machines to be reprogrammed more frequently, ideally without long downtimes. For medium-sized companies in particular, automation is only worthwhile if the robots can be utilized quickly and easily for smaller quantities too.



The automation sector would therefore be well-advised not to delay in developing technologies for easy operation. Looking into the automobile sector the potential here is not limited to graphical programming and voice control. In the latest generation of cars, infotainment systems can already be controlled with gestures.

Never losing sight of the target group

Large companies are increasingly concerned with the question of who the users of their products are and what desires and requirements they may have. "A person always performs a certain role, which in turn can be defined by certain characteristics," explains Jessica Rademacher, head of the Usability department in KUKA's Research and Development division. "We are creating software solutions to provide the best possible support for customers in carrying out their tasks successfully, efficiently and to their own satisfaction. The focus is always on the user."

But opinions vary in terms of whether a device or machine is easy to operate. After all, there are professionals and non-experts in all areas. And the age of the user also plays a role. Precisely these factors must be taken into consideration when developing new buttons, touch screens or controls.

Easy robot control with preprogrammed blocks

The aspects that work well on a smartphone also make the operation of robots easier. As a result, an increasing number of employees are able to program and operate robots without any formal skills. One of the simplifications is to use a widely popular programming language, such as Java, for programming robots. To make robot-based automation user-friendly even for employees who do not possess any programming knowledge, Java commands can be grouped into intuitively configured function blocks. In this scenario, the operator selects function blocks and

configures the desired sequence. So the complexity of text-based programming is never even an issue.

Easy programming and operation significantly reduces people's reservations about working with robots. One example of this has been implemented at the Technical University of Dortmund. The robot-based test environment is designed to train students for future production scenarios, to demonstrate the benefits of automation to companies, and to mitigate people's reservations. An important feature here is the robot controller, which can be simply programmed and operated by means of graphic elements. Users can select the desired robot program and expand it, if needed, without any special knowledge.

Hello robot – voice control makes it possible

There are also other options allowing robots to be easily commanded. "In the future, I want to be able to control robots by voice," says Dr. Rainer Bischoff, Head of KUKA Corporate Research. In this respect, robotics can benefit from smartphone developments, where voice-based input is already part of everyday life.

Thanks to more advanced sensors and algorithms, a lot has already happened in this field. Today, robots are capable of mastering even complex tasks with a high degree of autonomy, as Bischoff illustrates with an example: "The task is described orally, pretty much like a command that I might give to a person, 'I need a terminal. You can find one in our warehouse. Place it in a box and bring the box to my workplace.' Currently we are working on getting a robot to make decisions autonomously and to execute more demanding and varying tasks independently. In other words, we want to evolve the robot from apprentice to journeyman." <

KI



Martin Ruskowski is a professor at the Department of Machine Tools and Controls of the Technical University of Kaiserslautern. At this university and at the German Research Center for Artificial Intelligence (DFKI), he researches topics such as the interaction between humans and machines as well as Industrie 4.0. He previously worked for KUKA Industries, where he was responsible for global research and development.

ARTIFICIAL INTELLIGENCE

Man and machine in new harmony?



Sepp Hochreiter is a professor at the Institute for Bioinformatics of the Johannes Kepler University in Linz, Austria. The computer scientist researches topics such as machine learning and bioinformatics, among other things for genetic analysis and drug development.

It is a fascinating and polarizing technology: artificial intelligence (AI) is changing the world and giving rise to new possibilities. Above all else, Hollywood movies and exaggerated predictions have characterized AI in the past, arousing fears in many people. Sepp Hochreiter from Linz in Austria and

Martin Ruskowski from Kaiserslautern in Germany are renowned experts in the field of artificial intelligence. In a joint conversation, the two professors discuss opportunities and unrealistic expectations – and why it's not just humans who need time to learn more.

Professor Hochreiter, Professor Ruskowski: What is your definition of artificial intelligence?

Hochreiter: To me, it constitutes a machine with cognitive abilities which are generally ascribed to humans. This is also how John McCarthy defined it in 1956. Such a machine perceives the world, plans and draws logical conclusions to achieve an objective.

Ruskowski: In my view, artificial intelligence primarily comprises a group of special mathematical procedures. These facilitate, among other things, the recognition of patterns, machine learning processes and also the interaction of a machine with its environment in the sense described by Mr. Hochreiter. But the original definition by McCarthy goes too far, in my opinion.

Your definition, Professor Hochreiter, sounds as if the aim of AI is to create a "new" human being.

Hochreiter: A machine that looks like a human being but is not a human would give rise to too many ethical issues. It would be foolish. Rather, we should develop something that is capable of providing the best possible support.

Ruskowski: I agree that replicating humans makes no sense. We must distinguish, there are two approaches to AI: strong AI, which aims to understand how humans function, and weak AI, which expands the abilities of humans. The second approach is what we are pursuing at DFKI, the German Research Center for Artificial Intelligence, for example in terms of using AI for production. To us, AI is like an adapter between the digital and human worlds. We humans are not that great at processing large amounts of data, for instance. AI can handle the preprocessing, allowing us to make better and faster decisions on that basis.

Hochreiter: I don't think that is ultimately the goal. Strong AI is the more interesting route in my opinion. We are striving to build complete systems that can see, hear,

understand and handle objects. These universal systems can then be specialized: one cooks, another cleans and a third works as a roofer. Facebook, Google and Amazon are already working on such universal systems in their own fields, and so are automakers for the purpose of recognizing the environment for autonomous driving.

Ruskowski: I don't think that one system for everything is the way to go. I believe in diversification with many small systems, from which we pick specialized abilities that can then be combined on a modular basis. What concerns me about your approach is that a single player could monopolize the situation. A system like Facebook would have even more of an influence on our entire life.

Regardless of what approach we pursue, do you believe that AI will replace human workers?

Ruskowski: No. Look at Germany, for example: we have used automation for decades and still have full employment in many sectors. Even back in the 1980s, engineers dreamed of factories without people. It has never come true – thankfully. But why? Some think that AI is inexpensive or even free, but that's just not the case. These systems are so complex that their development entails considerable costs. This is the reason why AI will not readily replace humans in factories. Quite the contrary: by using these technologies, we can even bring industrial production back to Europe. This is assuming that we are successful in further developing the automation process: to date, humans have had to adapt to the machines. For the first time, AI makes it possible for automation to adapt to humans, meaning that machinery becomes a useful tool and attendant.

Hochreiter: I also believe that AI will yield more work, not less. Machines are becoming more intelligent and will be able to talk to humans. A lathe will be able to tell you that the lubricant is too hot or the chips are too long. Relieved of tedious tasks, humans will become teachers or instructors, and will only have to deal with exceptions, which are much more interesting.

Ruskowski: But we must not forget to involve employees and works councils from the beginning when such systems are introduced. The transformation has to happen from the bottom up, rather than being



“Especially because many of the scenarios that are presented to us at the movies are so absurd, it is important for us to define clearly in reality what AI is and what it isn't.”

"Machines are becoming more intelligent and will be able to talk to humans."



dictated from the top down. One important issue is transparency, for example, when it comes to monitoring technology.

Hochreiter: I agree, the user must understand what is happening, thus enabling him or her to actively participate.

Movies often portray artificial intelligence as menacing – is there any truth to that?

Hochreiter: It is true that many people are afraid of losing control, which would be virtually tantamount to domination by machines. But why would AI want to dominate humans when it requires different resources and habitats than humans, who are bound to the biosphere? Another argument against such gloomy scenarios is the fact that humans exercise selective pressure on AI, meaning that only useful and helpful AI will be further developed and reproduced. I am optimistic that this pressure will encourage us to develop productive AI.

Ruskowski: Especially because many of the scenarios that are presented to us at the movies are so absurd, it is important for us to define clearly in reality what AI is and what it isn't. This includes learning how to use it in a responsible manner and repeatedly explaining how AI works.

Hochreiter: Exactly. Why do we demand 100 percent perfection from AI from the start, but not from humans? Let's take autonomous driving, for example. Before humans are allowed to drive, they have to obtain a driver's license. Similarly, a machine must first demonstrate that it can accomplish

everything that it is asked to do, and that it can do so with adequate safety and resilience. But it is not liable to make certain mistakes. For example, it does not get tired and is not distracted by a cellphone ringing. In the long term there will be significantly fewer accidents thanks to AI.

How should we, the economy and society, get ready for AI?

Hochreiter: In terms of the legal framework, we need to catch up quickly. At the moment, there are many individual stories that are circulating in the press regarding things that can go wrong. I have had discussions with criminal lawyers. The circle of people involved with AI products has grown. This raises new questions: whose fault is it if something goes wrong when using a machine? The programmer, the sensor manufacturer or the people who have trained the system and fed it the data? We have to come to terms with the fact that we will not be able to pre-program all conceivable eventualities. After all, the very characteristic of AI systems is that they learn from perceiving their environment.

Ruskowski: We also need to make significant strides in education and training. Our current curricula are still very analog-based and humanistic, for example. Not that there is anything wrong with that, but they must be expanded. I have noticed that schools in many cases brush aside the digital world. As a result, young people are insufficiently prepared to responsibly handle digital opportunities such as AI.



Artificial intelligence and robotics

To an increasing extent, robots are no longer being used only in strictly organized production cells, separated by safety fencing, but are collaborating with humans in production operations or even have to find their way around a "chaotic" environment in domestic settings. Artificial intelligence helps robots adapt to such uncertainties and variability. Until now, robots have been repetitive, working with consistent precision and high repeatability. The requirements of the future are much more diverse, however. If robots are to handle everyday tasks, for example, they must be able to react flexibly to events in their surroundings. To achieve this, KUKA is using machine learning, a subdomain of AI. This involves learning procedures on the basis of examples instead of explicitly programming fixed sequences. But the same still applies: human experience and human creativity are ultimately irreplaceable.



THE RING AFTER THE CLICK

The world is on a digital shopping spree. Online shopping is more popular than ever, and customers are becoming ever more demanding. Be it stocking a constantly changing variety of goods or making environmentally-friendly deliveries in record time through congested megacities, logistics companies must prepare to face tomorrow's challenges.

From Christmas reindeer sweaters to fair trade organic coffee and freshly picked flowers, the choice of products on the Internet seems infinite. And after having clicked, customers wait for the fast delivery service to ring the door bell.

In Germany, around 67.6 percent of the population bought goods online during 2016, and the trend is increasing. The world reached a global milestone in 2017: for the first time, half of earth's inhabitants were online – and the number is on the rise. In addition, the global middle class will more than double between 2009 and 2030 according to an EU study. In summary this means there will be more people with Internet access who can afford to shop online – and will actually do so.

On the other hand, what customers don't appreciate at all is a long wait before the goods arrive. The DHL parcel

service reports that 85 percent of all online shoppers attach the greatest importance to quick and reliable delivery; 50 percent of the respondents said they had already aborted online purchases because the delivery options were too slow. Same-day delivery or next-day delivery are already offered by large retailers, but next-hour delivery is going to be the future standard.

Anyone who uses a car in the rush hour and tries to drive quickly through a large city will understand the challenges posed by these express delivery options. Therefore, experts are trying to work out quicker and more efficient methods of delivery and new types of warehousing.

"The warehouse of the future will be as compact as possible so that it can fit into any available space, with self-learning robots to make it flexible," says logistics expert Michiel Veenman from the Swiss automation

company Swisslog. That's because smaller warehouses are easier to locate close to residential areas. Urban distribution centers reduce the length of delivery trips, and save time.

With such flexible future technology concepts, automated warehousing systems can also be more quickly modified, so changes to the product range are no longer a problem. "The fashion industry has particularly short product cycles, with the assortment of goods changing continually," Veenman explains. Self-learning robots and software solutions help us manage the sheer endless diversity of products. The support provided by logistics robots can also overcome the problem of staff shortages in the industry.

Flexibility is immensely important, because the future "sharing economy" won't only be of interest for cars or music. Following this principle, warehouses could also be shared flexibly rather than purchased, taking the form of modular units that can be re-assembled like building blocks in a construction kit, and intelligent robots which immediately recognize a new renter with different products and then invoice their work on a service basis. Pay-per-pick instead of costly permanent storage.

This way, players in the fiercely competitive logistics market can respond to extreme fluctuations in demand. The Fraunhofer Institute for Materials Flow and Logistics has addressed the topic of urban logistics, and suggests using multi-story car parks, for example, as temporary warehouses when millions of people press the "Buy Now" button on their smartphones shortly before Christmas.

The "last mile" to the customer could also be shared. When dozens of drivers with half-full delivery trucks drive

along congested streets heading to the same address, this has an impact on the environment and infrastructure – and on the vendor's balance sheet. An efficient "shared last mile" with electrically powered delivery trucks would therefore not only save costs for the logistics companies but also reduce the burden on cities and the environment.

"With people and politicians increasingly expecting not only functioning but also clean, quiet and unobtrusive logistics, it is inevitable for logistics companies to address electromobility and new means of transport," says Prof. Uwe Clausen, Director of the Fraunhofer Institute for Materials Flow and Logistics (IML). "Delivery concepts without a driver in the vehicle for certain parts of the route will be really exciting," according to Clausen's prediction. "Stationary retail business will persist, but it will have to reinvent itself to keep customers interested."

We can only speculate on how the cities of the future will look, and on the pattern of our future shopping behavior. DHL has investigated various future scenarios in a study. Will we have access to a 3D printer in our own neighborhood, printing our desired products, just as nowadays we print our photos at the local drugstore? Will we live in megacities which function only through efficient logistics and where people rent things instead of buying them?

"Altogether, the study clearly shows that the role of logistics will change strongly in the coming decades. That applies to all the scenarios described in it," says Deutsche Post CEO Frank Appel in an interview about the study. "Common to all of them, however, is a highly encouraging message, especially for our industry: the demand for logistics services is set to grow in virtually all cases." <

Ideas for future logistics

Warehouse airships

In late 2016, a big online dealer made headlines when it became known that it had patented the idea of computer-controlled tethered airships. The plan: tethering the warehouse airships close to the city, where they would act as bases from which drones fly the goods to the customer.

The flying parcel service

Roads may be clogged, but airspace is clear – that saves time and cuts distances. This is the reason logistics companies are testing deliveries by drone. These small aerial vehicles would be capable not only of delivering purchases to city dwellers but also of flying goods to inaccessible places or transporting medication for humanitarian purposes.

Underground pneumatic tube system

Like a mole: several companies and start-ups are exploring the idea of delivering merchandise and goods via underground tunnel systems. This would allow products to reach their destinations without congestion or diversions, taking the burden off the streets and the environment at the same time.

One vehicle, many options

Some ideas address the possibility of extending car sharing to include the delivery of packages. Either the person renting the car could take the package with them on their journey and receive a discount on the car sharing charge, or autonomous vehicles could use their parking time to deliver packages.

REALITY PLUS

For a long time, only technology enthusiasts were thrilled about Virtual Reality and Augmented Reality. But today industry experts are convinced: the hype is now being followed by applications.



For just 25 cents, visitors were able to experience a historical milestone in the USA in 1962: the “reality machine” took them to another world. Those who sat down on the moving chair and put their head into the apparatus experienced a motorcycle ride through Brooklyn from the driver’s perspective. Real wind blew through their hair, the chair vibrated and tilted in the direction of travel. The Sensorama, as cinematographer Morton Heilig called his invention, is considered the first Virtual Reality appliance, a multi-sensory theater that enabled the audience to fully immerse themselves in the films.

But the futuristic apparatus never got beyond the prototype stage. “The Sensorama may have been too revolutionary for its time,” Heilig later stated in an interview, and he was most likely right. Because, for an innovation to be successful, the market timing has to be right as well.

And if you concur with the opinion of the IT market research company Gartner, the time has now come for Virtual Reality (VR). The company estimates in a study that, after periods of hyped expectations and subsequent disillusionment, Virtual Reality can be used productively within the next five years.

“The world is becoming more and more complex. VR and Augmented Reality (AR) can make certain subjects more comprehensible through innovative visualization, rendering them more tangible,” says Torsten Fell, board member of the First German Professional Association for Virtual

Reality. The possibilities are wide-ranging: “I can physically grasp data and adapt them, thus making it possible to experience big data or to move digital twins of machinery.” Even though it will still take some time until the technology is widely used: “Companies that are gaining experience with the technology now will be a step ahead in the future, as they will already be familiar with it.”

Researchers and developers have been experimenting with the countless technical possibilities for a long time: firefighters simulate highly dangerous situations in training and doctors are using VR in studies to treat anxiety and pain. In a VR simulation of the St. Gotthard base tunnel, workers were trained to ensure smooth operations underground without costly downtime. And at RWTH Aachen, forest workers are safely and realistically practicing off-road driving with a wood harvester by means of a 3D simulator on a KUKA robot.

“We have started working with technologies in this field and are developing solutions for our customers, in addition to finding solutions for optimizing our own processes,” says Kerstin Höfle, IP and Strategy Manager at Swisslog. This enables customers to explore their future warehouse with VR glasses, observe how employees interact with machines, or test how access routes and cables can be optimally positioned.

Augmented Reality (AR), in other words expanding the real world with virtual objects, is also very promising. The first AR pilot





projects with digital support for service technicians and remote maintenance are underway. The use of a headset like the Microsoft HoloLens allows users to see 3D projections in their real environment, such as additional product information or simulations. A large furniture store is using AR to help their customers see what the virtual sofa could look like in their living room.

“We enhance the real world with information, so to speak,” says Thomas Kirner, team leader for virtual commissioning at KUKA. Working with Virtual Reality has been part of his everyday life for many years. His team creates digital images of systems, and these virtual machines are then programmed. If everything works as intended, the software is used on real systems. This saves time and money and allows customers to walk through complex production cells that would be visually inaccessible in reality, and it enables them to get a detailed view of their system in operation. 3D glasses are not always needed. Frequently, a monitor suffices.

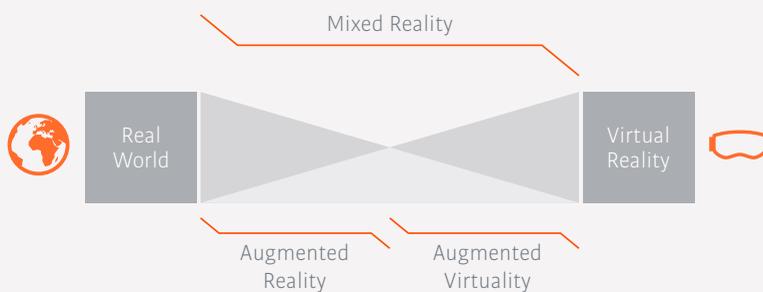
At first glance, people wearing the bulky, black headset look somewhat isolated, but in reality VR can facilitate cooperation, such as during joint project work in a virtual space while the teams are actually in different locations. It may even help employees work more creatively in the future. Because in the virtual world meetings can also take place in front of a breathtaking mountain panorama or on the beach instead of in a dreary conference room. <

Augmented Reality: The real world is augmented with virtual objects and information, such as instructions or tips. As a matter of fact, probably the most popular AR application to date is a computer game: in Pokémon Go, users catch digital fantasy creatures in the real world.

Augmented Virtuality: “Augmented Virtuality” flips the relationship between virtual and real: real objects or people are inserted or displayed in a virtual environment.

Mixed Reality: In “Mixed Reality”, virtual and real elements are combined to different degrees. This can range from a real environment with some virtual objects (AR) to a digitally created environment with people or real objects in it.

Virtual Reality: Users can also completely immerse themselves in a computer-generated world by means of special glasses or virtual rooms. This effect is called immersion and is one of the core characteristics of Virtual Reality. Users move about in Virtual Reality and interact with it in real time.



Tradition meets innovation

KUKA is celebrating its 120th anniversary this year.
All events around the orange birthday can be found
at www.kuka.com/KUKA120



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