Fraunhofer

TRENDS IN INDUSTRIE 4.0

CONTENT

SAFE, FLEXIBLE, INTUITIVE

Three small adjectives – safe, flexible, intuitive – that sum up what companies are looking for in the production of the future: customized production right down to a batch size of one. As connectivity spreads to the way we manufacture, consume, work, communicate and even act, digital solutions are pervading every sector – all the way from manufacturing to energy supply. This is affecting existing business models, transforming established market structures and shifting the balance of the global market. There is no doubt that companies must confront these new challenges posed by Industrie 4.0, and Fraunhofer is ready to step in with solutions catering to a full range of scenarios. Our expertise calls on years of research and development spent investigating topics such as factory automation, logistics, sensor technology, ICT and many other fields indispensable to us today. Cyber-physical systems gather sensor data and use it to regulate the flow of materials, goods and information. This transforms rigid factory lines into modular and efficient systems that conserve resources.

Workers are supported by assistance systems that pave the way for new forms of human-technology interaction. The economic potential is huge. According to a study conducted by Fraunhofer IAO and BITKOM, and looking at just six main sectors of the economy, Industrie 4.0 could precipitate a boost in productivity worth some 78 billion euros by the year 2025.

This brochure showcases a sample of applications: targeted networking of production data allows workers to spot errors earlier, halving downtimes; new wireless communication technology establishes connectivity to IoT platforms; highly complex small-batch production is executed using sophisticated robot control. And in the "StemCellFactory" Fraunhofer researchers are demonstrating that the comprehensive networking of machines and products is coming to biotechnology, too.

Prof. Dr. Reimund Neugebauer

Prof. Michael Schenk, Chairman of the Fraunhofer Group for Production and Director of the Fraunhofer Institute for Factory Operation and Automation IFF

"PEOPLE WILL REMAIN THE FOCAL POINT IN INDUSTRIE 4.0, TOO"

An interview with Prof. Michael Schenk, Chairman of the Fraunhofer Group for Production, on the opportunities and challenges presented by Industrie 4.0.

Professor Schenk, to what extent will Industrie 4.0 transform the way that industrial companies work and think?

On the one hand, consumers and producers will be more digitally interconnected in the future, thus giving rise to a high level of product customization. On the other hand, demand will only exist for products combined with digitized services related to production. Digital added value will exceed pure product value, and the creative and work processes in product design, development and production will merge. This shift will be rapid and sweeping and increasingly facilitated by artificial intelligence tools. Expediently collecting and analyzing all of the data in the value chain, i.e. big data, in near real-time enables us to boost workforce and energy productivity.

Companies are using cyber-physical systems to customize more products. Custom products are cheaper to manufacture. Where are the major technological hurdles and where is there need for research?

The protection of personal data of customers and employees, known as cybersecurity, will play a major role and will have to be carefully treated and facilitated in the future. I consider the continued presence of gaps in the broadband coverage in Germany, especially in the eastern states, to be a problem. Broadband availability is very patchy there. Action must be taken quickly to remedy this situation. Here, I would draw attention to the Industrial Data Space, an initiative launched by the Fraunhofer-Gesellschaft. Researchers are working in a funded project on reference architecture for secure data spaces and its implementation since companies' retention of sovereignty over their data is the prerequisite for Industrie 4.0.

There is also a completely different kind of hurdle: If we are to make custom products on equipment from different manufacturers, then these machines have to be able to communicate with one another. Common standards are still nonexistent even for this lowest level of "smart connectivity". Industrie 4.0 has sparked discussion on this issue, at least. Things get even more complicated when, for instance, semantic "understanding" and autonomous deduction of consequences for subsequent manufacturing operations are required in addition to pure data transmission. We are only at the very beginning of a development here, which still requires a great deal of research.

Small and medium-sized German companies often still have problems identifying the potential of Industrie 4.0. How can we make them aware of these opportunities so that they stay abreast of global developments?

SMEs often do not have the human resources, let alone experts, to deal with this paradigm shift extensively over the long term. Building and expanding government subsidized model factories and learning platforms can provide valuable support here. Special attention should

also be paid to technical trades. The concept of "Trade 4.0" has not been introduced but it plays an important role in implementation in the system and supplier network. The paradigm shift aspired to will only occur when every institution with a stake in the overall value added can partake of and participate in "4.0".

This change entails numerous challenges for employees. What are the central issues?

People will remain the focal point in Industrie 4.0, too. We can increase employees' skills by systematically introducing digital learning and assistance systems and by developing individualized training and coaching programs. We increasingly need digital tools. Physiological stresses can be reduced by human-robot collaboration, for instance, while psychological stress can be minimized by adaptive and visualizable handling of data streams, for instance.

What research projects is the Fraunhofer Group for Production pursuing to integrate humans in manufacturing so that they have healthy workplaces in every stage of their professional lives as automation advances?

At present, the group is designing socio-technical production systems that factor in the demands and needs of humans in Industrie 4.0, especially in light of demographic change. Methods, models and procedures for technologically assisted learning in data-intensive processes are already being developed and implemented extensively. This requires upgraded human-machine interaction and enhanced forms of machine learning. All of the group's institutes are working on related projects with industrial partners.

What actions is the Fraunhofer Group for Production taking to design workplaces of the future?

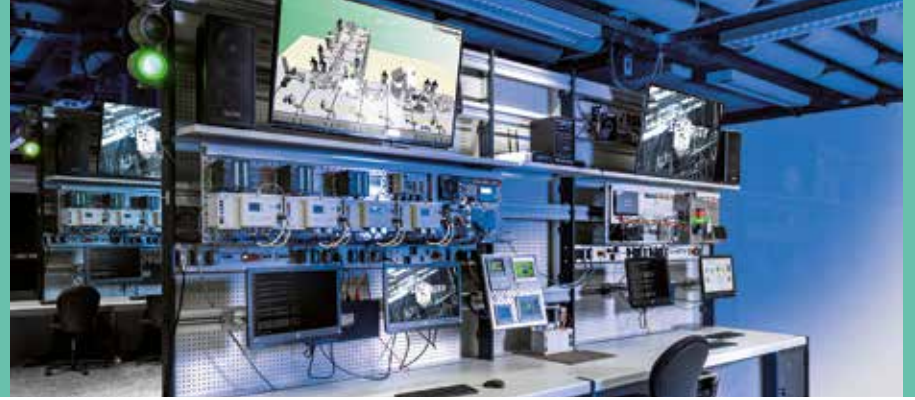
Related activities are wide-ranging and geared toward manufacturing systems with specific workstations. They are chiefly focused on collaborative human-robot systems, user interfaces for different equipment and varied forms of assistance systems.

How is Fraunhofer helping companies make the switch to Industrie 4.0?

We are helping companies in a wide variety of ways, from performing "Industrie 4.0 CheckUps" in companies and organizing industrial forums together with professional associations and chambers up through building demonstrators such as model factories and learning platforms. Of course, projects are being completed with many partners.

"Made in Germany" stands for quality German engineering. How do German industrial companies stack up against their international competitors with respect to Industrie 4.0?

Implementing Industrie 4.0 enables industrial enterprises to offset comparatively high unit labor costs and energy costs in capital-intensive business. This could be termed "digital productivity" and describes the level of efficiency with which a company handles its own and third party data in its creative and value-added processes. With Industrie 4.0, we will strengthen and expand our international competitiveness in machinery and equipment manufacturing.



SECURE PRODUCTION IN INDUSTRIE 4.0

IT security is one of the key conditions for the success of Industrie 4.0. The merging of production and services with the Internet is opening up new points of attack for cybercrime and industrial espionage. Fraunhofer researchers offer reliable solutions to protect networked production facilities against such attacks.

Industrie 4.0 networks require special protective measures, sophisticated network technology and effective testing methods to uncover vulnerabilities in the system and reliably eliminate them. The IT security laboratory at the Fraunhofer Institute for Optronics, System Technologies and Image Exploitation IOSB in Karlsruhe is specially equipped for production and automation technology. Here, the IOSB offers a secure test environment in which to simulate potential attacks on production networks, examine the implications of such attacks, and develop suitable countermeasures and strategies. The IT security laboratory has its own model factory with real automation components that control and monitor a simulated production process. In this laboratory, which is specially equipped for production and automation technology, researchers can simulate a factory's entire hierarchical IT infrastructure – including the office network as well as the networks for planning, monitoring and controlling production. With their own private cloud, the IOSB experts can install different customizable configurations and set the model factory to run various scenarios. "In the cloud, our researchers can create new factory environments and simulate cyberattacks with no need to purchase any components or lay any cables," explains Prof. Jürgen Beyerer, director of the IOSB.

National Reference Project for IT Security

Three Fraunhofer Institutes are contributing their expertise to the National Reference Project for IT security in Industrie 4.0 (IUNO): the Fraunhofer Institute for Applied and Integrated Security AISEC, the Fraunhofer Institute for Secure Information Technology SIT and the Fraunhofer Institute for Experimental Software Engineering IESE. The aim of the project is to provide effective protection to networked industrial facilities against cyberattacks and espionage. Traditional security concepts cannot simply be transferred. For example, confidentiality takes top priority in office IT, whereas IT systems in production facilities need to provide availability above all else. When existing IT security solutions detect a threat to system confidentiality, they automatically curb the availability of the systems under attack. But in a production facility, such a mechanism means production downtime. Together with 18 partners from industry and research, Fraunhofer is creating practical IT security solutions for Industrie 4.0. The IUNO project is funded by the German Federal Ministry of Education and Research.

Industrial Data Space for the secure exchange of data

The most frequently expressed fear about Industrie 4.0 is that data is not secure, commercial secrets go missing, and internal company information is disclosed to the competition. Against this background, the Fraunhofer-Gesellschaft's Industrial Data Space initiative is developing a network of trusted data. This provides a secure data space that enables companies of all sizes in various industries to network their data while retaining sovereignty over it. For more details, please see the interview with Prof. Michael Schenk on page 4.

ADJUSTING PRODUCTION PROCESSES IN REAL TIME

Industrie 4.0 requires extensive data collection in order to control highly automated process sequences in complex production environments. One example is the cultivation of living cells. Using fully automated equipment for producing stem cells, Fraunhofer researchers have managed to adjust the process control to cell growth – delivering an adaptive system that is suitable for use in a number of sectors.

The term Industrie 4.0 is generally associated with the manufacturing of cars, machinery or industrial goods. But, as the partners in the StemCellFactory collaborative project show, the comprehensive connectivity of machines and products is also making headway in biotechnology.

This is a particular challenge, because this field deals not with solid components but with living objects that change and multiply. The process control needs to take this into account and be able to adjust the process in real time.

The StemCellFactory project partners have set up a fully automated production line for cultivation of stem cells, which can develop into any kind of cell found in the body; experts call them induced pluripotent stem cells. These cells are necessary in the development of drugs used in personalized medicine. They are generated from adult body cells such as human skin cells. "We believe that the data generated by cellular systems such as these has a considerably higher predictive value with regard to the effectiveness of any individual drug," says Simone Haupt, head of bioengineering at Life & Brain GmbH and a partner in the StemCellFactory project.

Fully automated, modular production platform

The project aimed to develop fully automated, modular equipment that achieves both a high throughput and a consistently high quality of stem cells. The experts from the Fraunhofer Institute for Production Technology IPT were given the task of developing both the equipment and its control software. When the project started there were no standardized interfaces for lab automation equipment, the researchers had to establish their own standard for connecting the devices used and for enabling the process-control technology and the lab equipment to exchange information. That in turn was the prerequisite for integrating the equipment flexibly and adjustive to the biological processes at work. Cell growth and viability are the decisive factors here. As the cells grow in the cell culture vessels, they divide again and again.

To this end, the microscope developed at the IPT regularly examines the growth density inside the cell culture vessels. Once a critical density is reached, the microscope sends out an instruction to transfer the cells. "This is an example how the product, in this case the growing stem cells, determines the overall process," says IPT researcher Michael Kulik.

The technology developed as part of the StemCellFactory project can also be applied in other situations, for instance in tissue engineering and the production of tissue models. It would also be possible to use it to manufacture gears, screws, engines, etc. in a fully automated way. Since the programming is extremely flexible, the process-control technology can be transferred to any other production setup in need of adaptive control on the basis of current metrology data.

PRODUCTION WITHOUT RIGID PLANS

Opinions differ on how to set up flexible production that works as quickly – and as cheaply – as line production does. Fraunhofer IPK is organizing production to operate without fixed chains, turning human coordination and decision-making skills into a key component of sequence control.

Underlying the term Industrie 4.0 is the idea that in the factory of the future, machines will communicate directly with each other, with workpieces and with human workers. The ultimate goal is for production to organize itself. It is precisely this goal that the Fraunhofer Institute for Production Systems and Design Technology IPK aims to achieve by putting people at the center. Human workers wield the power to make decisions about the production sequence, and receive help in making those decisions from high-performance tools. Take gear manufacturing: presently, gears are manufactured in firmly linked lines that connect, say, milling machines and turning machines to each other in a chain. If one machine goes offline, the entire line shuts down. Another drawback with line production is that it is expensive and time-consuming, if not actually impossible, to manufacture multiple gear families simultaneously. "If you want production to be more flexible, it is a promising idea to break up the conventional chains," says Adam Opel AG project manager Dr. Benjamin Kuhrke, who is coordinating the joint iWePro research project. In German the name is short for "intelligent self-organizing job shop production".

Grouping machines into cells

One alternative to the line concept is job shop production. In this configuration, machines that carry out similar tasks are grouped together in cells – for example, several turning machines are clustered in a turning-machine cell or several milling machines become a milling-machine cell. "If you do that, you need methods that guarantee products will progress swiftly and reliably through the entire production process. Otherwise a work step may be left out or an order might get stuck halfway through production because no one knows where to send it next," says Eckhard Hohwieler, head of Fraunhofer IPK's Production Machines and Systems Management department. Here's where the Berlin-based researchers' work comes in. They have created an integrated Industrie 4.0 factory that replaces fixed links with a new kind of process organization without sacrificing the reliability of line production. IT-driven tools ensure that employees at all hierarchy levels receive the information they need at any time in order to play their part in the punctual manufacturing of the product – whether it be in process management, production planning, or final assembly.

To make it possible to manage job shop orders as the situation demands, the researchers and their industry partners are currently developing an agent system that monitors implementation of the production plan. The agents – components of the agent system software – supply employees at the various job shop stations with information about which machine is slated for the next processing step. They can also provide assistance when ad hoc rescheduling is required, for example if a machine stops working.

http://s.fhg.de/ipk-industrie-40

PRESSWERK 4.0 TO CUT DOWNTIMES IN HALF

It costs companies dear to have machines out of operation due to failure. This applies to press plants, too, the area of focus for Fraunhofer's Presswerk 4.0 project. Researchers want to employ targeted data networking in manufacturing to help employees recognize and correct failures more quickly – and reduce failure-related downtimes by at least half.

Steel sheets are delivered in huge rolls to the press plant, where they are first cut to the required size. Then they pass through several presses to be stamped into the desired shape – a car door, for instance. If, however, workers discover a crack in the component, they have to reject it; after all, each subsequent process step costs money. Things get really tricky when the fault is not a one-off occurrence but rather affects all the components coming from the press. Then workers have to stop the press and start troubleshooting. Is the problem due to the raw material or the lubrication? Is the press not running properly? It takes a while to check out all the parameters and possible faults – during which time production is at a standstill.

The right information, at the right time, in the right place

Researchers at the Fraunhofer Institute for Machine Tools and Forming Technology IWU have made it their mission to develop Industrie 4.0 in the field of mechanical engineering. One of their areas of focus is the press plant of the future. "We combine the various streams of data in our Linked Factory, a data and service platform developed here at the institute. From that, we generate new information that we can provide to staff, for example on mobile devices," explains Sören Scheffler, a scientist at the IWU. On the basis of this data, researchers are able to isolate the cause of a failure more quickly and make targeted suggestions to staff as to how to rectify it as quickly as possible. Together with partners from industry and science, the IWU is working on reducing failure-related downtimes by around 50 percent. The aim is also to help operators react more quickly and flexibly to market needs and customer preferences, even when plans change at short notice.

The researchers' first step is to build on data that is already being collected – by sensors or camera systems, for instance – since standard production information is rarely sufficient to identify a problem. In the future, a software application will collect this data centrally, associate it with the other information, and thus generate new knowledge. In the case of the faulty door, for example, it will merge data from the sensors in machine tools with information about lubrication and data on the raw material used; then it will check which values lie outside the pre-defined tolerance limits in each case. On the basis of these results, staff will receive suggestions for troubleshooting options to enable them to solve the reported problem in a targeted way. In the long term, researchers want to develop the system further to the point where it can issue a warning even before a fault has arisen.

STATE-OF-THE-ART TECHNOLOGIES FOR THE FACTORY OF THE FUTURE

Scientists at Fraunhofer's research factories in Chemnitz and Stuttgart-Vaihingen are working with industry to test out solutions for the automotive manufacturing of tomorrow.

In May 2014, the E³-Forschungsfabrik Resource-Efficient Production opened at the Fraunhofer Institute for Machine Tools and Forming Technology IWU in Chemnitz. Scientists here are collaborating with partners from industry to conduct research into solutions that will enable tomorrow's manufacturing to be resource and energy efficient.

This research factory in Chemnitz focuses on two areas of technology: car body manufacturing and the production of powertrain components. For example, scientists are carrying out research on car body production facilities that can be used flexibly to build different models in a car manufacturer's range. Until now, each model has needed a new production line. In the current research project with VW, Audi, Phoenix Contact and Kuka, the components needed for any one model are identified in the warehouse and delivered to the facility by means of networked logistics. The robots and grippers on the line then use actuators (drive units) to self-adjust for the production of the model at hand.

In addition to energy, material, time and cost, data is also becoming an ever more important manufacturing resource. The E³-Forschungsfabrik´s own information system correlates data from over 1500 sources – gathering data on operating states, energy consumption or mainte-

nance schedules, for example. This allows new forming-based process chains to be analyzed, optimized and tested under factory conditions.

ARENA2036: research factory for the car of the future

On the ARENA2036 campus, scientists from the Fraunhofer Institute for Manufacturing Engineering and Automation IPA and from the University of Stuttgart are collaborating with companies such as Bosch, Daimler, Festo, Kuka and BASF. They are working together in a research factory on developing and manufacturing lighter, eco-friendly cars that can be customized and produced individually at affordable prices.

Around 5000 square meters of the University of Stuttgart campus in Vaihingen have been set aside for a research workshop and manufacturing facility. It is in this realistic setting that the scientists are due to carry out research into tomorrow's vehicle designs and manufacturing processes that will replace assembly line production. The facility's foundation stone was laid in October 2015, and construction is expected to be completed by the end of 2016. The project partners want to replace the largely inflexible production line model that has existed until now with a manufacturing process that depends far less on conveyor belts and cycle times. "It is the task of ARENA2036 to develop sustainable automotive manufacturing methods and to support a technology transformation that will enable personal mobility with low energy consumption. The key lies in versatile forms of production networked in real time," concludes Prof. Thomas Bauernhansl, Director of the IPA.

www.e3-fabrik.de/en

Prof. Wilhelm Bauer,
Director of the Fraunhofer Institute
for Industrial Engineering IAO

DIGITAL COLLABORATION BETWEEN HUMANS AND MACHINES

An interview with Prof. Wilhelm Bauer, acting director of Fraunhofer IAO, about the impact of Industrie 4.0 on the workplace.

Professor Bauer, last year Fraunhofer IAO initiated some pioneering research projects focusing on the digitalization of the workplace. Where do you see key developments in the coming years?

It's clear to anyone who follows current issues in business, politics and society that digitalization is going to bring about huge changes in the way we live and work. From my perspective, there are three important elements in that regard: human beings, with our modern needs and behaviors; new (and sometimes, disruptive) business models; and technology, with digital and information technology leading the way.

What impact will the digital transformation have on our daily lives?

The Internet and digital technologies are changing our everyday working lives significantly. Digital work practices have already come a long way in the office environment: we can work wherever, whenever and however we wish. And as artificial intelligence systems become more prevalent, they will make further significant changes to office and knowledge work. These developments are now also making headway in our factories: in the Internet of Things, smart networked objects communicate with each other as well as with people. Through this, we'll receive another push in automation – a positive change given our demographic situation.

Won't these developments serve to increasingly widen the so-called "digital divide"?

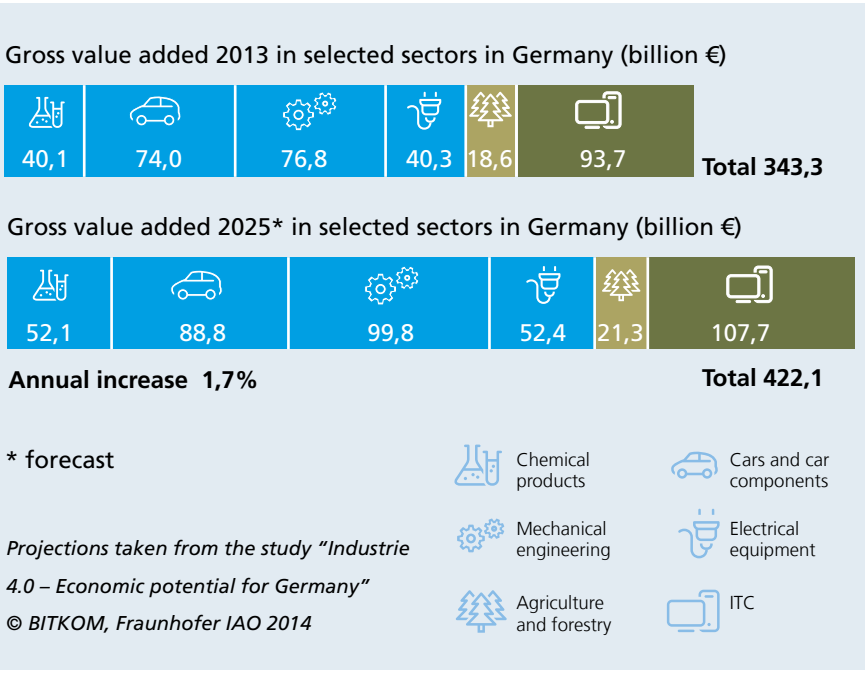
Yes, there is that danger. On the one hand you have the tech-savvy young people from Generations Y and Z, who socialize digitally and are "always online." They use digital technology quite naturally, including in their place of work. On the other hand you have the needs of older people, who do not find this approach so natural. We have to take them with us too into tomorrow's digital world of work, because we don't want to lose anyone with valuable qualifications as we move forward.

That requires appropriate further training measures. Setting up mixed-age teams is a good option as well. In addition, we need to have digital technology that is so user-friendly it can be handled quite readily by people of every age, culture and level of qualification. Technology therefore has to be easy to use.

"Industrie 4.0" – how will the developments involved drive forward manufacturing companies?

The Internet of Things and Services puts us at the start of the next industrial revolution, which we call Industrie 4.0. In practice, this means that manufacturing companies will develop digitally enriched products – that is, cyber-physical systems. And these new products will be produced in smart factories by digital and connected manufacturing systems with increasingly intelligent automation. Digital platforms will support the production of smart products throughout the entire value chain – from customer need to customer benefit.

GROWTH POTENTIAL OFFERED BY INDUSTRIE 4.0



What potential do you think Industrie 4.0 has for the economy?

That's a key question, of course, which we already explored as part of a study with BITKOM in 2014. This study revealed that Industrie 4.0 has the potential to revolutionize our industrial value creation in the same way as the Internet has revolutionized knowledge work. In order to realize the full potential of Industrie 4.0, we need to take a holistic approach to creating the people-technology-organization ecosystem. We also need standards governing technology and practice as well as regulations covering fast and seamless communication, data protection and data security. That's something we're working on in Fraunhofer's Industrial Data Space initiative, for instance.

How will Industrie 4.0 become a reality? What do you see as the challenges in implementing it?

Industrie 4.0 must be introduced gradually. To that end, we need to gain experience through research and practical implementation. At the same time, it is important to train people for digital ways of working and to familiarize them with new processes. In this country we have huge potential for this, but only if we serve as providers of essential technologies and not just as a market for them. It's true that we are leaders in machinery and plant engineering, but we still lag behind when it comes to data handling. Some people say that Germany and Europe have lost the first half of the digitalization game. But now the second half is beginning – and here it's all about the real world, basic needs and the digitalization of the real economy. That was always our strength, and we now have excellent chances of succeeding.

So, are human beings coming more to the fore now in human-machine interaction?

From examples such as hearing implants, wearable body sensors or collaborative robots, we see that intelligent machines – and indeed, intelligent technology in general – are adapting more and more to individual needs and abilities. However, we are only at the beginning in this respect. Now we need to create user-friendly applications and include various user groups in the design and development process. Integrated and interdisciplinary research must be central to our approach. We should give examining ethical, social and legal issues the same priority as we do scientific, technical and economic questions. In order to do this, we need a new kind of socio-economic research that encompasses technology within it.

RADAR WITH 360° VISION

Nowadays it is impossible to imagine industry without robots. Fraunhofer researchers have designed a new high-frequency radar scanner that makes 360-degree scans of the environment and prevents collisions between people and machines. As the system also penetrates optically opaque materials, it even works in conditions of poor visibility.

In businesses that follow smart Industrie 4.0 principles, people and machines are interacting more and more with each other. A prerequisite for this level of co-working is that people must not be endangered at any time – but that is precisely the Achilles' heel of collaboration between people and robots. Currently, laser scanners are used to monitor the danger zone around machinery, and to stop the machine as soon as a person enters the zone. However, optical sensors do not always achieve reliable results under changing light conditions. They also do not work if there are any obstructions to the line of sight.

Researchers at the Fraunhofer Institute for Applied Solid State Physics IAF have developed a compact modular 360-degree radar scanner that is superior to optical sensors in many respects. The radar works with millimeter waves at a frequency of 94 GHz and a bandwidth of 15 GHz. In contrast to optical sensors, millimeter waves penetrate all non-metallic and optically opaque materials such as clothing and plastic or even dust and fog. The high-frequency module, which is the key component of the radar scanner, was developed by IAF researchers in close collaboration with the Fraunhofer Institutes for Reliability and Microintegration IZM and for Manufacturing Engineering and Automation IPA.

MAKING THE UNEXPECTED PLANNABLE

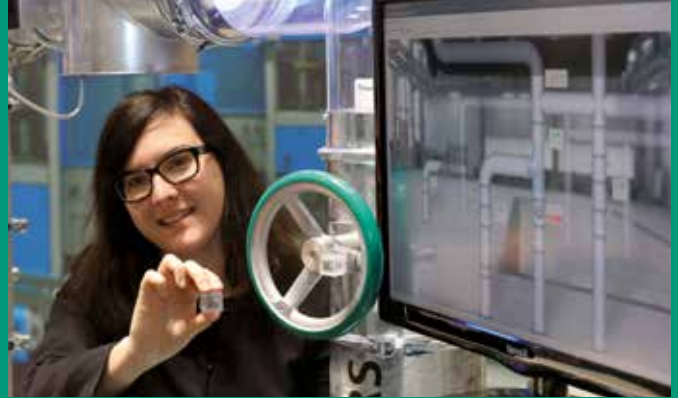
In Industrie 4.0 robots have cognitive abilities in order to communicate and cooperate with humans and other technical systems. Fraunhofer researchers demonstrate with the DUPLOcator how a machine can recognize what to do next.

Manufacturing customized products in small volumes in a cost-effective way – that is one of the aims of the fourth industrial revolution. In this process, frequent configuration changes prove to be a great challenge. The Fraunhofer IGD DUPLOcator is capable of dealing with this unpredictability.

Industrie 4.0 sees robots working predominantly with sensors. The DUPLOcator also works according to this principle: it uses cameras to create a model of a structure made from model building blocks and recognizes the structure's assembly plan. After that, it uses its modern robot arm and the building blocks provided to build the structure on its own.

"To make sure this works, we combine recognition algorithms with precision self-learning robot control mechanisms," explains Prof. André Stork of Fraunhofer IGD. The requirements are minimal: the DUPLOcator must be able to see the structure properly with its camera eye and have access to the same component parts. "The DUPLOcator concept could be of particular benefit to assembly fitters processing small series of highly complex components," says Stork.

http://s.fhg.de/duplocator



INTERNET OF THINGS FOR THE INDUSTRY OF THE FUTURE

Objects are becoming smart: they are aware of their status and can communicate with other objects. This is also known as the Internet of Things. Using the examples of a new wireless communication technology and cloud-supported maintenance of combine harvesters, Fraunhofer researchers show how industry is benefiting from this networking.

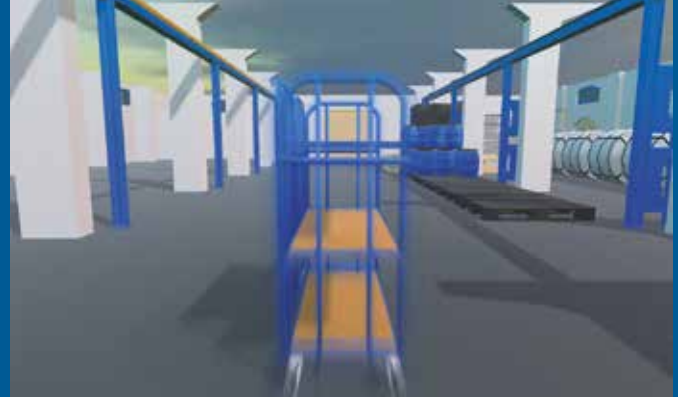
The Internet of Things allows objects to become smart and "talk" to each other, by equipping them with sensors that record the status of objects and transmit this data to a central location. Such transmissions could, of course, be made using a cellular phone network, but it is energy-intensive and expensive. Moreover, messages are sometimes not completely transmitted. The Fraunhofer Institute for Integrated Circuits IIS has come up with an alternative: The Fraunhofer IIS MIOTY wireless communication technology, which can facilitate the networking of as many as one million radio nodes. Each individual node requires only a fraction of the energy needed for conventional cellular communications, and the battery lasts for ten to fifteen years. The transmitters can communicate with a receiver up to ten kilometers away. Instead of sending all the data bundled together, the researchers split it into small packets. This data is transmitted at intervals on different frequencies, which makes the transmission less susceptible to interference. To demonstrate how the technology works, the IIS researchers use an industrial piping system. This transmits its data to a mobile platform, allowing factors such as humidity, movement, light and temperature to be transferred.

Cloud-supported maintenance of combine harvesters

Objects' intelligence is important in the case of combine harvesters, too. After all, these are effectively factories on four wheels, and they need to have an extremely high level of reliability. If a machine like this goes wrong at harvest time, it can be some time until replacement parts are obtained and an appropriate specialist is flown in from another part of the world. This entails a major financial loss for the farmer. Researchers at the Fraunhofer Institute for Embedded Systems and Communication Technologies ESK know how to reduce such expensive unscheduled stoppages in the future – or even how to avoid them altogether. Their principle is to have a number of sensors on every machine monitor the key components of the drive system and use a cellular phone network to send their data to a central maintenance service in the cloud. With the aid of online analytical procedures, this service can detect any irregularities very early – and raise the alarm. As a result, components can be replaced even before the machine stops working. This process is also known as "predictive maintenance." Together with partners from industry, the ESK has designed a cloud-based solution that will make this possible for machines throughout the world.

High Performance Center for Digital Networking

The High Performance Center for Digital Networking is a collaborative venture involving the four Berlin-based Fraunhofer Institutes FOKUS, HHI, IPK and IZM. Researchers here are developing technologies and solutions that take into account the increasing digitalization and networking in every area of our lives. Research is focused on basic and interface technologies as well as on solutions applicable to the areas of health and medicine, mobility and the city of the future, industry and production, and critical infrastructure.



LOGISTICS: TACTILE POWER STEERING FOR ORDER PICKING CARTS

In the future, the process of steering vehicles in logistics centers will be more intuitive, thus making work easier and safer for employees. Fraunhofer researchers have developed tactile handles, which use pressure sensors to recognize in which direction operators are pushing or pulling their carts.

Logistics center workers use forklifts, industrial trucks, and motorized carts to transport loads from point A to B. Fully loaded carts can weigh up to 500 kilograms; at present they are steered using a control panel with five to ten buttons. Now, thanks to tactile handles being developed by researchers at the Fraunhofer Institute for Factory Operation and Automation IFF in Magdeburg, operators can steer motorized carts with very little effort, merely by applying hand pressure. This is made possible by pressure sensors built into the handle. Since the handle is equipped with sensors for both hands, a cart knows more than just whether it is being pushed or pulled; software that compares the pressure from the right and left hand enables the cart to register the particular direction in which it is being moved.

This system transmits an operator's hand-pressure commands to the motor. "We are working with our colleagues at Cloud&Heat Technologies GmbH to transfer all employees' commands to a cloud and collect and coordinate them there," says Prof. Klaus Richter, the expert group manager at the IFF. If a cart being taken around a blind curve is at risk of colliding with another cart, both carts will be stopped automatically. It takes just 10 milliseconds for the signal to travel from the tactile handle through the cloud back to the motor control unit. "The stated goal of the Tactile Internet is for human-machine interfaces to be tangible.

We are bringing this vision a bit closer to reality," says Richter. "The tactile handle is an extremely interesting application of the new forms of cloud computing on which we are working. This innovative approach depends on a very low-latency connection to the cloud," adds Marius Feldmann, COO of Cloud&Heat Technologies GmbH.

FAST Realtime research project

The tactile handle is being developed in the FAST Realtime research project, which is primarily being driven by the mobile communications industry and is also a part of the 2020 Cluster Strategy. The project with total funding of 50 million euros is intended to develop new human-machine interfaces. Whereas the purpose of the Internet of Things is to interconnect individual objects, the "Tactile Internet," is about defining human-machine interfaces that are more effective and more intuitive as well as safer.

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Photo acknowledgments
Cover: iStockphoto
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