



HIGHLIGHTS
2018
ANNUAL REPORT

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Link to further information about the topic



Link to multimedia contents

FRAUNHOFER IIS

The Fraunhofer Institute for Integrated Circuits IIS in Erlangen is one of the world's leading application-oriented research institutions for microelectronic and IT system solutions and services. It is the largest of all Fraunhofer Institutes.

Research at Fraunhofer IIS revolves around two guiding topics: audio and media technologies and cognitive sensor systems. Applications for the research results are found in connected mobility, in communication and application solutions for the Internet of Things, in the digitalization of human sensing, in product and material monitoring and in business analytics in supply chains.

Almost 1050 employees conduct contract research for industry, the service sector and public authorities. Founded in 1985, the institute has 15 locations in 11 different cities: Erlangen (headquarters), Nuremberg, Fürth, Dresden, Bamberg, Weischedel, Coburg, Würzburg, Ilmenau, Deggendorf and Passau. The budget of 165 million euros a year is mainly financed by contract research projects; 26 percent of the budget is made up of German federal and state funds.

Cover picture

Fraunhofer IIS's localization and analytics technologies are the basis for the Jogmo system currently being used in the National Hockey League (NHL). It offers more information about players and the game in real time than was ever possible in ice hockey before.

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PUTTING KNOWLEDGE TO USE

Dear reader,

Getting up close to the action – that is what fans, the media and coaches want. And digitalization in ice hockey has made it possible: The jogmo tracking system delivers data about player and puck positions, yielding new insights and information.

We also successfully put our knowledge to use in other projects in 2018: In the Annual Report, you will find articles about hybrid radio, about the successful market launch of the fourth generation of audio coding formats, about 5G, about digitalization in rural areas and about the management of data from X-ray imaging.

In 2019, the Fraunhofer-Gesellschaft celebrates its 70th birthday. Our success is based on looking forward, developing original ideas and systematically implementing innovations. Artificial intelligence and machine learning are major digital topics of the future. We view them as powerful tools for tackling previously unsolvable problems in applied research.

Maybe you, too, have an idea for the future? We look forward to working together.

Best regards,

A handwritten signature in black ink, appearing to read 'Albert Heuberger'.

Prof. Albert Heuberger

A handwritten signature in black ink, appearing to read 'Bernhard Grill'.

Dr. Bernhard Grill

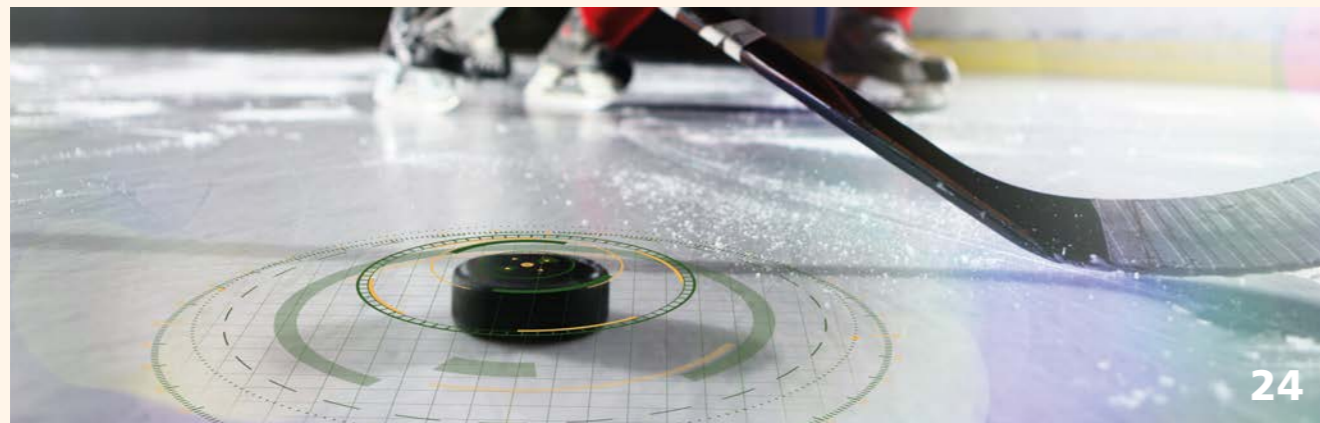
Directors of Fraunhofer IIS



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RADIO WITHOUT LIMITS

Hybrid radios merge analog, digital and Internet radio together. They allow users to listen to a regional radio program even when they are outside its broadcasting range. We offer software solutions that enable car radios to use all three sources. Furthermore, our audio codecs ensure good audio quality even at low bit rates.

Whether radio is played in the kitchen or in the car, the analog radio waves of traditional radio broadcasting are increasingly also being used for the transmission of digital signals. In addition to the now widely adopted digital radio systems such as Digital Audio Broadcasting (DAB+) and Digital Radio Mondiale (DRM), Internet capability is also increasingly being incorporated into radio receivers. These so-called hybrid radios allow users to receive Internet radio as well as FM and digital radio.

These devices are especially useful on the move, as they enable people to take their favorite local radio station with them wherever they go, even outside its broadcasting range. For example, if a Bavarian is driving in Berlin and wants to listen to a program from back home, the car radio automatically offers them the Internet livestream. Once back in Bavaria, the radio reverts to DAB+ or – when traveling in an area where the digital terrestrial signal cannot be received – FM.

Hybrid radio in your car

With their time-proven mix of information and entertainment, traditional radio programs will continue to be popular with drivers and passengers in future. A flexible use of the various

AT A GLANCE

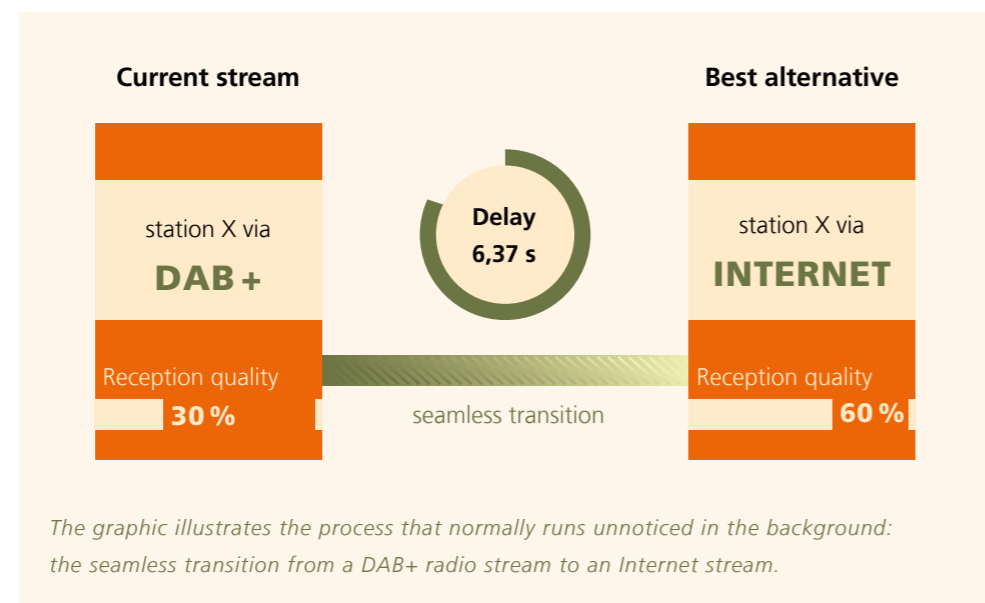
- 1 | Hybrid radios merge analog, digital and Internet radio together.
- 2 | Hybrid radio combines the advantages of a radio system with the possibilities offered by an Internet connection.
- 3 | Fraunhofer Sonamic TimeScaling delivers a precise, imperceptible transition.

“YOU COULD ALMOST SAY IT WAS A RADIO APP IN THE VEHICLE.”

transmission routes and technologies allows the vehicle entertainment system to meet people’s higher demands for greater quality and choice.

Car users can listen to their favorite radio station at all times. The radio seeks out the best source for this service. This can be digital radio, an Internet stream or even traditional FM radio. Modern radio platforms that use our radio software components are able to make this selection in the background and, if required, to switch from one source to another, so listeners scarcely even notice if the reception conditions in the moving vehicle change. The flexibility afforded by the use of software components also offers the option of configuring the same radio platforms for different markets or vehicle classes and of simply upgrading them in the future. You could almost say it was a radio app in the vehicle.

The audio program is supplemented by data services such as pictures, text notifications and further additional information that can be used via the specified receive paths. Here, hybrid radio combines the advantages of a radio system with the possibilities offered by an Internet connection.



Seamless transitions

Compared to a radio signal’s reception, a web stream can have a delay of 20 seconds or more. When switching to the web stream, portions of the delayed feed are either lost or played twice;

both of which are irritating to the listener. Fraunhofer Sonamic TimeScaling synchronizes both signals with each other to produce a precise, indistinguishable transition. This involves either delaying or accelerating the signal, so that an inaudible overlay is possible.

The process also works in reverse, when the system recognizes that the radio signal is strong enough again for good reception. This means it can seamlessly switch from the web stream to the radio signal while keeping the amount of mobile data used for Internet access to a minimum.

Ensuring high audio quality

Alongside additional services, radio stations primarily create and maintain audience loyalty by offering them listening pleasure. In digital and web radio, this means using the best audio codec, which has to deliver maximum quality at the lowest possible bit rates. For growing numbers of streaming services and for the DRM digital radio standard, the system of choice is the xHE-AAC (Extended High Efficiency AAC) codec.

This newest member of the AAC family unifies speech and audio coding for the first time. As a result, the range of usable stereo bit rates is expanded to between 12 kbit/s and up to 500 kbit/s or higher. xHE-AAC was developed specifically for adaptive streaming, and alongside MPEG-H Audio, it is the only codec that switches seamlessly between the available bit rates and quality levels. The audio bit rates required have been reduced by up to 50 percent compared to the predecessor HE-AAC codec while offering comparable quality.

Listening to your favorite station wherever you go

With hybrid radio, you can listen to your favorite station in your car even when you leave the broadcast range. In such cases, the radio broadcast is seamlessly combined with the corresponding Internet stream. Fraunhofer’s Sonamic TimeScaling technology delivers inaudible transitions. Fitted with SDR platforms, car radios have the technology required to receive web streams. In the future, operation of the radio receivers is to be simplified, so users will not even notice what path the radio program they are listening to is being transmitted on.

« SDR platform
A software-defined radio platform makes radio systems configurable and flexible, thereby enabling new radio functionalities.



Hybrid radio in India

In India, for example, the world's largest digital radio rollout is progressing well. The public service broadcaster All India Radio (AIR) is making the national terrestrial radio infrastructure fit for the future, to which end it is using the digital radio standard DRM. This standard is the only one that fulfills all requirements for the coverage of a huge country like India and guarantees the efficient and complete digitalization of radio, irrespective of whether the programs are supposed to be receivable on a local or regional, a national or even international basis.

For a seamless transition from analog to digital radio, AIR is currently transmitting both analog and digital broadcasts simultaneously. The digital contents are encoded with the xHE-AAC codec standardized in DRM. As xHE-AAC is optimized equally for speech and music contents, it is no longer necessary to change the configuration of the digital radio according to the type of audio contents currently being broadcast.

In India, the automotive industry has really got behind DRM: at the start of May 2018, the number of cars fitted out with DRM radios exceeded 800,000. Almost all leading manufacturers have already integrated DRM into their vehicles, including Hyundai and Suzuki.

This means hybrid radio will continue to be an important technology in India in the future. Depending on the reception at a given time, the radio can then switch automatically between DRM and the station's xHE-AAC livestream on the Internet, so as to ensure optimum quality and interruption-free radio enjoyment. ■

1 Car radio with DRM receiver in India.



www.iis.fraunhofer.de/sonamic



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MPEG-H SELECTED FOR CHINESE 3D AUDIO STANDARD

Fraunhofer IIS is technology supplier for 3D sound in 4K UHD TV

China's AVS 3D Audio Task Group has chosen Fraunhofer IIS as the transmission audio codec solution provider for the upcoming 3D Audio standard that will be used in the country's 4K UHD broadcast. Fraunhofer proposed its MPEG-H TV Audio System according to the requirements of China's next-generation broadcasting audio standard in order to meet the Chinese market demand for compelling audio.

„Our team in China is excited to start helping Chinese broadcasters and CE manufacturers deliver the excellent immersive and interactive audio features of the MPEG-H TV Audio System to consumers at home and on the go“ said Toni Fiedler, representing Fraunhofer IIS in China. Fraunhofer IIS recently presented its end-to-end MPEG-H TV Audio System at Asia's

largest tradeshow for broadcasting technology and equipment, China Content Broadcasting Network 2018 (CCBN). The exhibits included a live broadcast chain demonstration with real-time authoring and monitoring systems and MPEG-H encoders, as well as a Digital Audio Workstation (DAW).

In 2018, the reliability and market readiness of MPEG-H were demonstrated when the system was used at the Eurovision Song Contest, the soccer World Cup and the European Championships in Berlin and Glasgow.

 www.audioblog.iis.fraunhofer.com/mpeg-h-china

FIRST RUSSIAN-SPEAKING SMART SPEAKER

“Fraunhofer upHear VQE” helps intelligent speakers understand commands

Yandex, a technology company that builds intelligent products and services powered by machine learning, has incorporated Fraunhofer's upHear Voice Quality Enhancement technology into its first smart speaker, enabling the device to accurately hear voice commands issued from anywhere in a room.

Fraunhofer's upHear Voice Quality Enhancement ensures that Yandex's new smart speaker, Yandex.Station and the embedded intelligent assistant Alice, can hear intelligible verbal commands. Fraunhofer provided a software solution that enhances the signals collected by the microphone array technology for far-field voice capturing. This ensures that Yandex's highly reliable keyword spotter and speech recognizer receive a clean voice signal.

upHear VQE removes interfering sounds captured by the smart speaker's microphones, extracts the user's voice and cancels out acoustical echoes. Fraunhofer's upHear Voice Quality Enhancement solution supports full-bandwidth audio and is a suitable voice enhancement step for a wide range of applications, including natural language understanding in mobile and smart home devices. It is a fully integrated and flexible solution which enables full-duplex conversations and barge-in support with outstanding audio quality.

 www.audioblog.iis.fraunhofer.com/yandex

xHE-AAC AND MPEG-D DRC IN NEW ANDROID PIE

Both technologies are now an integral part of Android 9

Android Pie comes with a string of major upgrades in terms of audio playback, since the Extended High-Efficiency AAC (xHE-AAC) audio codec and MPEG-D DRC Loudness and Dynamic Range metadata, both substantially developed by Fraunhofer IIS, are mandatory components of the operating system. The xHE-AAC implementation used by default in Android Pie has been provided by Fraunhofer IIS and is available as part of the FDK2 AAC Codec Library for Android.

Service providers and app developers that want to use xHE-AAC to distribute content can contact Fraunhofer to get access to professional xHE-AAC encoder software or work with one of our streaming equipment partners, such as Modulation Index or Telos. A technical white paper on xHE-AAC and MPEG-D DRC explaining the major use cases, benefits and engineering details is available online.

The advanced features of xHE-AAC enable video and audio streaming providers worldwide to offer an enhanced, more reliable consumer experience. The codec can deliver transparent quality for customers on a good network connection and can also seamlessly shift to the bit rates supported by a congested network while on the go. This is particularly of interest to streaming providers active in emerging markets where consumers still rely on 2G or 3G connections.

xHE-AAC – a fourth-generation codec and the youngest member of the MPEG-AAC audio codec family – expands the spectrum of usable stereo data rates, which now ranges from 12 kbit/s up to 500 kbit/s or higher. xHE-AAC was developed specifically for adaptive streaming; alongside MPEG-H Audio, it is the only codec that switches seamlessly between the available data rates and quality levels. The audio bit rates required have been reduced by up to 50 percent compared to the predecessor HE-AAC codec. This frees up data capacity, which can be used to improve the video quality.

In addition, MPEG-D DRC – Loudness and Dynamic Range Control – provides mandatory loudness control for xHE-AAC to play back content at a consistent volume and offers dynamic range control processing to provide the best possible user experience for listening on any platform and in any environment.

 www.audioblog.iis.fraunhofer.com/xheaac-mpeg-d-drc-android-pie

2 The codecs provide a reliable experience when listening to music or watching a TV series.



CUSTOMIZING RADIO BROADCASTS

The EU's "ORPHEUS" project provides tools and applications for object-based media production

Object-based media is an advanced approach for creating and deploying interactive, personalised, scalable and immersive content. Key tools and apps for implementing object-based media for audio content have been developed by ORPHEUS, an EU-funded research project performed by ten major European media industry players.

Examples are the adaptation of the dialogue level, the flexible playback on any end device or the variable length of a program. In addition, this technology can be used both for live broadcasts via various distribution channels and for on-demand offerings. To this end, the media objects are joined together in a novel way that allows them to be adapted to the needs of users, the acoustic environment and the device platform.

In 30 months of project duration, the consortium ran two successful pilots to demonstrate the key features and benefits of object-based broadcasting, including immersive sound, foreground/background control, language selection, and enhanced programme services. Pilot 1 was the first ever live object-based interactive radio drama, and was produced using the BBC's IP Studio platform. Pilot 2 premiered the introduction of variable-length functionality for audio. These pilots have proven the advantages of object-based media as a universal, innovative approach for media production and its applicability in real-world broadcast environments.

An evaluation version of the ORPHEUS app for iOS, which demonstrates the project achievements using the pilot productions made by BBC and BR, is available upon registration from the project website. These productions show the advantages of object-based audio in a broad range of radio formats, including live football report, documentary, radio drama and music.

 orpheus-audio.eu

 www.audioblog.iis.fraunhofer.com/orpheus-final-workshop

3 In May 2018, the results from the ORPHEUS project were presented in Munich.

easyDCP – TEN YEARS FOR DIGITAL CINEMA

Approved software for mastering of DCPs and IMFs

In just ten years, easyDCP post-production software has earned a globally recognized market position among post-productions, studios and all filmmakers who want to create a cinema package. The software is used for the creation, playback and quality control of digital cinema packages (DCPs) and interoperable master packages (IMPs). easyDCP has also been incorporated into further well-known post-production tools.

The easyDCP software meets the specifications of SMPTE and the DCI (Digital Cinema Initiatives) for digital cinema; its development was an important step in making digital cinema a reality. In this way, even non-digital natives can continue to easily and reliably create films for the big screen.

With the latest development, the easyDCP Publisher, users can opt for an on-demand licensing model – for example, if they want to create only a handful of DCPs per year. On top of this, filmmakers are now also able to switch directly from Final Cut Pro to the easyDCP Publisher ecosystem in a continuous workflow and carry out edits and optimizations as often as required. The next challenge will be to convert the workflows to cloud solutions, which we will address for new easyDCP developments.

 www.audioblog.iis.fraunhofer.com/easydcp

  www.iis.fraunhofer.de/easydcp


JPEG XS – NEW CODEC FOR VIDEO OVER IP

Compression standard for the transmission of high-resolution video data

As the amounts of video data with high resolution and advanced dynamics constantly rise, demand is also growing for the ability to respond flexibly to this challenge through the use of standard Internet protocols. Many production companies and studios in particular are searching for solutions to replace dedicated cables and switches for video transmission with conventional and more cost-efficient Ethernet infrastructures.

With the advent of JPEG XS, filmmakers now profit from a compression standard that is suitable specifically for so-called IP workflows in studio environments, for local video networks and above all for virtual- and augmented-reality applications. With this standard, it is possible to transmit high-resolution video data up to 8K and 60 images per second in production quality even with limited bandwidth or limited computing

power. Our scientists have developed an encoder and decoder solutions based on JPEG-XS that can be used in particular for transmissions with compression rates from 2:1 to 10:1. This solution can be integrated into existing hardware or software systems – such as in cameras, video switches, monitors and VR glasses – and is available as a licensable solution.

 www.audioblog.iis.fraunhofer.com/jpeg-xs-sdk

  www.iis.fraunhofer.de/jpegxs



5G – THE COMMUNICATIONS WHIZZ

The fifth-generation mobile communications standard is about much more than just a faster wireless network. Rather, 5G is a cellular network that offers the right solution for every requirement and is optimized for the Internet of Things. We are working hard so that the future of mobile communications will soon be operational in buildings, factories and vehicles.

We all know the feeling. A run-down battery, a poor Internet connection or sluggish download speeds can render a smartphone effectively useless. This raises an important question: How is wireless connectivity supposed to work in much more sensitive applications such as machine control and autonomous driving if our more modest everyday uses already push wireless networks to their limits?

No global, universal communication without a standard

With the arrival of 5G, we have a mobile communications standard that can do more: global in scope, very reliable and with very low latency, it will enable safety-critical applications such as autonomous driving. It is so extremely energy-efficient that sensor nodes can run on a single battery for years; it is so fast that machines can be controlled in real time; and it is so precise that users can exactly locate connected objects at any time.

Intensive work is underway to implement 5G, particularly within the 3GPP (3rd Generation Partnership Project) standards organization. This is where all the various strands relating to defining and adopting the 5G standard come together. In technical working groups, various

« Real time
A precise definition for “real time” does not exist. The time range can vary from one application to another. However, there is a golden rule: systems should work without any noticeable delay.

AT A GLANCE

- 1 | 5G is more than mobile communications, because the standard enables new industrial and mobility applications as well as high-speed Internet.
- 2 | Technology development for 5G includes coming up with transmission solutions, creating prototypes and testing.
- 3 | After publication of the standard, the applications must be tested. This requires special test facilities.

companies and research institutions discuss about the elaboration of individual aspects of the 5G specifications.

Our experts from the “Communication Systems” and “Positioning and Networks” research areas are actively involved in the development of the standard, whether through technical contributions or by participating in the respective working groups. The solutions developed as part of the standardization process are channeled into the 5G standard, which will be published in successive releases. A first draft of the 5G standard (Release 15) was adopted in June 2018. Work is now underway on Release 16, ushering in the second phase of 5G standardization.

Technology development as the basis for standardization process

Our contributions to the standardization of 5G are based on our research and development work into making wireless communication faster, more reliable and more energy-efficient and into making positioning more precise. To achieve this, we are working closely with partners in various vertical industries and know both their requirements and the capabilities and limitations of current technologies. This results in technical procedures and solution concepts that we can introduce into the 3GPP working groups in the form of suggestions.

Our technical solutions are geared toward various areas of application: For mobile broadband communications, we develop technologies such as multiple antenna systems and distributed antennas for increasing capacity and throughput. In the domains of Industrie 4.0 and connected mobility, the focus of development activities is on ultra low latency and precise localization and positioning. For the massive connectivity of objects in the Internet of Things, by contrast, the main thrust of research work is aimed at lowering power consumption through particularly energy-efficient transmission techniques. In addition, we are working on concepts for the integration of satellites into the wireless network, which has the potential to significantly improve complete worldwide network coverage.

Our technology development brings together various kinds of expertise: Development work on communication and localization technologies begins with the application-oriented system design, in which the functional concept of a transmission or localization solution is worked out. Then comes the practical realization. That is to say, we translate the solutions into initial hardware and software prototypes in order to test whether the technologies deliver the desired performance. This requires realistic test environments, which we have developed here at the institute.

Multiple antenna systems »

Multiple antenna systems use multiple antennas for signal transmission and receiving on both transmitter and receiver ends. In this way, they achieve higher data rates.

“CONTRIBUTIONS TO THE STANDARDIZATION OF 5G ARE BASED ON OUR RESEARCH AND DEVELOPMENT WORK.”

Testing and implementing 5G applications

Test environments are central to the tasks that will have to be accomplished even after publication of the 5G standard. Companies have to develop planned products and applications based on the latest mobile communication technologies that are not yet supported by the existing wireless networks. Although initial commercial 5G networks are expected as early as 2020, it may well take three to four years between the definition of new 5G functions and their general availability. In this period, the testing and development of future-proof communication applications will be very difficult without suitable test facilities.

With the “5G Bavaria” initiative, we offer companies and other research institutions the opportunity to test their 5G applications in advance. In the test center at Fraunhofer IIS in Erlangen, for example, we look after the development, maintenance and provision of test environments for simulations in the laboratory. With the installation of test beds, we also create application-specific test environments, such as for Industrie 4.0 applications in Nuremberg. They incorporate real infrastructure to implement initial 5G applications on a small scale – so that 5G can take up residence in buildings, factories and vehicles as soon as possible. ■

« 5G Bavaria
The 5G Bavaria initiative is sponsored by the Bavarian Ministry of Economic Affairs, Regional Development and Energy.



www.iis.fraunhofer.de/5g-en



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3

BEAM HOPPING TESTED LIVE OVER-THE-AIR

Adaptable beams make satellite communications more flexible and efficient

Contingent on the different time zones on the Earth, the data requirements of users vary according to time and place. The data volumes that can be transmitted via satellites to the Earth are subject to fixed capacity planning. In accordance with this planning, the Earth is illuminated with satellite beams, as it were, supplying it with data. To date, these beams have been static and always transmitted the same volume of data to a given area. However, local demand is not always as high as the capacity permits. And this spare capacity may be needed elsewhere.

The DVB-S2X satellite communications standard features a technique called beam hopping, which enables beams to literally “hop after” data demand. In collaboration with WORK Microwave in ESA’s “BEHOP” project, we developed beam-

hopping-capable test equipment with which we were able to successfully test the technique for the first time in 2018 using a Eutelsat satellite. The concept and the technology are thus ready for operation.

This satellite-based technique makes it possible to meet the rising demand for worldwide communication on land as well as in aircraft and ships. The commissioning of a satellite that supports the beam hopping technique is planned for 2020.

 www.iis.fraunhofer.de/beamhopping-en

1 Part of the test equipment:
beam-hopping payload emulator.

ALL CUBESATS IN POSITION

First multi-band GNSS antenna brings CubeSats into orbit position in real time with centimeter precision

CubeSats are small satellites in low Earth orbit (LEO) that offer completely new application possibilities by virtue of their constellation and characteristics. Combined in a mega-constellation, they can establish high-speed connections, for example, thereby supporting the existing network infrastructure on the ground. They can also be used in this formation for Earth observation. A prerequisite for doing this is that operators always know precisely where the CubeSats are located in orbit.

This exact real-time positioning can be established with the help of existing satellites in the GNSS (Global Navigation Satellite System) – such as GPS, GLONASS, Galileo and BeiDou. To this end, small broadband antennas are required that sit on top of the CubeSats and are able to receive the GNSS signals. And it was precisely this that presented the biggest technical

challenge before now, as the need for a higher bandwidth usually comes at the expense of antenna size. With the multi-band GNSS antenna, these seemingly conflicting requirements have been successfully resolved for the first time. As well as being extremely compact and cost effective to produce, the CubeSat antenna also supports all GNSS signals in the L-band, which allows centimeter-precise GNSS real-time positioning in orbit.

 www.iis.fraunhofer.de/antennatec

2 A multi-band GNSS antenna,
measuring just 82 mm × 82 mm
× 9.5 mm, installed on a CubeSat
model.

IOT NODES TRANSMITTING DIRECTLY TO SATELLITE

New technique for direct satellite connections at extremely low transmit power

Traditional satellites in geostationary orbit (GEO satellites) are located around 36,000 kilometers from the Earth. To overcome this distance and reach the satellites by radio normally requires high-power transmitters with very large antennas.

Our new transmission technique, by contrast, enables smaller transmitters and antennas to transmit small amounts of data, such as sensor data, directly from the ground to a GEO satellite. The technique uses a waveform that has been specially optimized for low data rates, which ensures successful transmission even at extremely low transmit power. For optimum use of the technique, we have also developed a C-band antenna that measures only approximately seven centimeters in diameter.

The new technique reduces transmit power sufficiently to allow the waveform to be operated below the threshold at which regulatory restrictions for the C-band apply. As a result, the technique can be used with antennas that require no alignment and will still not interfere with other satellite systems. Another advantage of the solution is that it can be operated using small, cost-effective transmitter and receiver terminals that have long battery lives.

This transmission technique is a special development for Internet of Things applications via satellite (Satellite IoT). Such IoT connections via satellite are always a helpful solution in situations where small amounts of data have to be transmitted but there is no mobile communications or terrestrial IoT network infrastructure available. They enable applications such as temperature and humidity monitoring in agriculture, and condition monitoring for oil and gas infrastructure for maintenance purposes and to detect leaks early on.

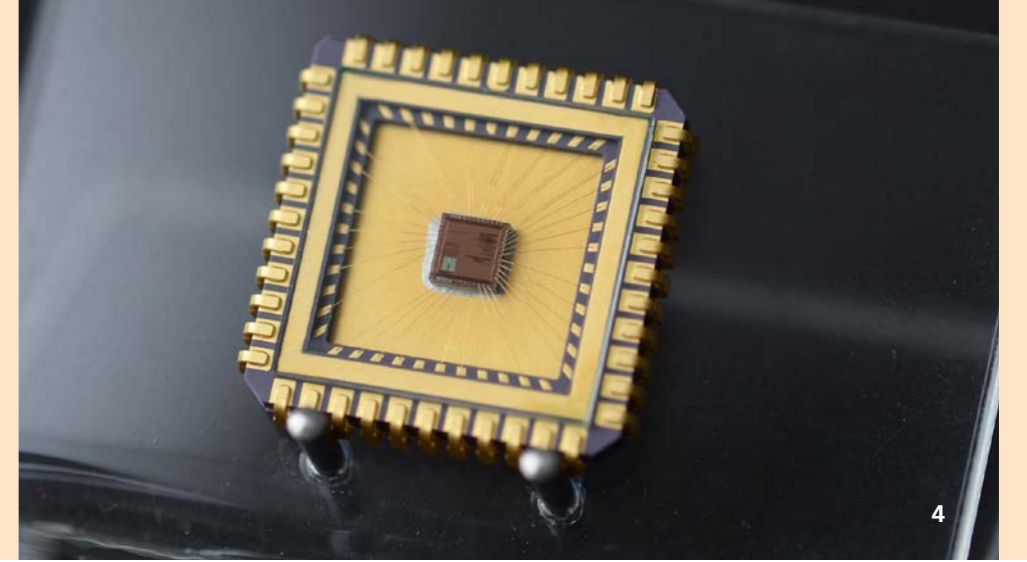
A technology demonstration has shown that the technique works in practice. This involved several portable transmitters equipped with the C-band antenna acting as IoT sensor nodes and transmitting their GPS positioning data via a GEO satellite.

 www.iis.fraunhofer.de/satelliten-iot-en

3 The small C-band antenna in the foreground uses a special transmission technique to transmit IoT sensor data directly to a geostationary satellite.



5



4

FAIL-SAFE VEHICLE ELECTRONICS

Service life of electronic assemblies in cars can be increased to between 25 and 35 years

Electronic systems in cars and aircrafts are becoming increasingly smaller, more complex and more sophisticated. However, this miniaturization results in a greater sensitivity of electronic components to external stresses.

In the RESIST project, we worked together with partners to re-search concepts into creating very reliable and robust designs for especially high-performance micro- and nanoelectronic components. We developed a new approach that permits predictions during a microchip's design phase of its subsequent behavior in operation. We also developed special chip components that recognize when wear is about to cause a failure and can report the issue to the vehicle driver or maintenance service. In addition, novel components designed for robustness protect integrated circuits particularly well against electrostatic

discharges, which can shorten the service life of electronics. Taken together, these measures substantially support the goal of increasing the lifetime and failure safety of electronic assemblies in future automotive and aviation applications from 10-15 years at present to 25-35 years in the future.

 www.eas.iis.fraunhofer.de/project-resist-en

4 RESIST early warning system:
Sensor for monitoring the functioning of an integrated circuit.

MORE ROOM FOR ADAPTIVE SYSTEMS

Groundbreaking ceremony for new building at our EAS division in Dresden

Right next to the campus of the Technische Universität Dresden, a new building is currently being built for our EAS Engineering of Adaptive Systems division. This will greatly improve the conditions in which our Dresden site can carry out research work into complex electronic systems, intelligent sensor technology and automation solutions. In particular, the numerous spaces for experiment halls, electronics laboratories and measuring rooms, which make up more than a quarter of the usable floor space, will offer the researchers ideal conditions for new developments.

the longstanding site on Zeunerstrasse. A capital budget of some 25 million euros was set aside to complete the building. Around 20 percent of this total comes from the German federal government, around 20 percent from the Free State of Saxony and around 60 percent from the European Regional Development Fund (ERDF).

 www.eas.iis.fraunhofer.de/new-building-dresden-en

The future workspaces are expected to be ready for occupation in 2020. With total floor space of around 4,300 square meters, the new institute building on Münchner Strasse will be about twice as large as the currently available spaces at

5 New building at EAS division of
Fraunhofer IIS.



SPORTS TRACKING – DIGITALIZATION IN THE FIELD OF SPORT

Sport is a magnet for millions of people around the globe. And team sports played in huge stadiums are all about the energy that reaches us as spectators watching the action live or transmitted to us in the comfort of our own homes via digital media. Sports officials and fans want access to a range of relevant information and background analyses. This is where jogmo comes in – a sports tracking system for data on player positions, ball or puck position, and the physical fitness of players that is brought to you in real time and with unprecedented precision.

Digitalization is fast infiltrating virtually every aspect of our lives - and it's no different with sport, with fans and spectators increasingly expecting to be directly connected to sporting events. Players and coaches expect in-depth insights from player or object position data to allow them to change tactics mid-game. In training situations, objective, continuous athlete fitness monitoring is just as important because it enables coaches to tailor training programs to get the best performance outcomes. Given the strong competition in sports leagues or between teams and service providers, those with the lion's share of information along with quick and easy access to game action will be the ones to succeed. In complex, fast team sports such as hockey the use of tracking and data analytics systems paves the way for sports reporting of the future and creates an entirely new way of engaging sports fans, taking the experience of the game straight to you in the comfort of your home or at the tap of a button on your smartphone.

AT A GLANCE

- 1 | Tracking and data analytics systems represent a breakthrough in advanced reporting for an immersive experience of team sports.
- 2 | Players and trainers expect detailed insights data on the positions of the players and the ball or puck, so they can instantly optimize their game tactics.
- 3 | With the spread of digitalization, spectators and fans expect to be directly connected to sporting events.

1 jogmo tracking system for game stats and data analytics



2 jogmo displays players' vital signs during the game in real time

The systems approach to positioning

In professional sport, the benefit of the jogmo tracking system is its systems approach, which is tailored toward the specific challenges associated with team sports. The tracking system uses a combination of local positioning technology, signal processing, and wireless technology centered around a dedicated microelectronic integrated circuit to meet the practical requirements for interference immunity, 3D data precision, and temporal resolution. The result is a system that delivers what it promises – reliable and accurate live sports tracking for games played in major sports halls and arenas. After all, the only way to analyze or grasp the sheer complexity of dynamic team sports such as hockey or soccer is to track every single movement, every single player move across the entire rink or field. To do so, the position of people or objects fitted with miniature radio transmitters are calculated, analyzing runtime differences between the signals it picks up. Dedicated antennas with a defined phase center, installed around the rink or playing field, receive the wireless signals and transmit them to a central computer unit. Positions are updated as many as 2,000 times a second and to within just a few centimeters. To facilitate worldwide use, the system operates in the 2.4 GHz frequency band commonly used across the globe.

“From the try-outs to the dug-outs”

Originally developed as a soccer analytics system, jogmo was first installed in a pilot set-up in Max-Morlock Stadium in Nuremberg and at TSG 1899 Hoffenheim. It was also tried out in Leinster's stadium in Dublin when there were Rugby European Cup holders.

“Out onto the ice” – let the game begin!

The hockey league teams have a particularly strong affinity for tracking technology. And it was this very environment that set the benchmarks for a winning system: robustness, speed and precision. Radio-based tracking systems have many a challenge to surmount: strong reflections off the surface of the ice, high speeds and the momentum of the game, frequent quick subbing, and strong signal interference from thousands of people in the stadium using WiFi networks operating in the same frequency band. On top of this was the not insignificant matter of integrating the microchip into the puck – the electronics and the battery have to be able to withstand speeds of up to 160 kilometers per hour and acceleration forces of up to ten times the force of gravity across a 60-meter-long, 30-meter-wide rink. In fact, the level of mechanical robustness required is comparable only to aerospace applications. Plus, the dimensions, weight and, for example, elasticity of the puck have to remain identical, with no

“SKATE TO WHERE THE PUCK IS GOING TO BE, NOT WHERE IT HAS BEEN.”

Wayne Gretzky – All-time NHL great

difference between the microchipped puck and a conventional puck in terms of robustness and performance.

Since 2014, the radio-based tracking system has been being used for live data feeds and real-time analytics for hockey games. In 2015, having undergone continuous improvements, a pilot system was installed at Nuremberg stadium, home to the Thomas Sabo Ice Tigers. The pilot system was used during training and in the play-offs for the German Ice Hockey League. Learning about jogmo in the trade press, representatives of the National Hockey League (NHL) visited the stadium in Nuremberg to see the system for themselves and get a better picture of its capabilities and potential. Tests in the Prudential Center in New Jersey soon followed in 2016 as part of an international tracking systems evaluation program run by the NHL. The results speak for themselves: jogmo ranked far higher in terms of accuracy, reliability across the entire surface area of the rink as well as its integrated systems approach. Fraunhofer IIS demonstrated successfully the tracking technology throughout the 2018 NHL All-Star Game in Tampa, Florida. In January 2019, jogmo was showcased at the Consumer Electronic Show (CES) in the T-Mobile Arena in Las Vegas. In the same month, the player and puck tracking technology was demonstrated at the NHL All-Star Game in San José, California. ■

  www.iis.fraunhofer.de/jogmo-en



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MASTERING COMPLEXITY WITH COGNITIVE TECHNOLOGY

Designing more efficient workflows and processes for the industry

Through the Cluster of Excellence for Cognitive Internet Technologies, the Fraunhofer-Gesellschaft is promoting the development of cognitive Internet technologies for a “new Internet for industry.” Cognitive sensor technology solutions, data sovereignty, data economy concepts, and new machine learning methods are making workflows and processes more efficient in the domains of industry, manufacturing, logistics and mobility. Machinery and equipment, workpieces and cargo goods can be reliably identified, located and continuously tracked.

The IoT-Comms project is all about the use of cognitive sensor technologies and secure transmission in logistics applications. Positioning technologies and edge analytics precisely record data in real time and then forward it. In addition, sensor-based

analysis makes it possible to promptly transmit recommendations for action to the personnel concerned. When transporting a highly sensitive medical device, for example, this solution can detect during transportation whether an item has been damaged redundant, or is so badly impaired that local repair teams should be dispatched on site, or even whether a brand new piece has to be sent out. New cognitive technologies make it possible to master these complex relationships in supply chains and offer transparency and trustworthiness of data and data analysis.

3 IoT-Comms provides prompt recommendations for action to the relevant personnel.

THE “LAST MILE” FOR IOT COMMUNICATIONS

MIOTY® is based on ETSI transmission standard

In developing the MIOTY® wireless transmission technology, we have created one of the first standardized communication solutions in the industrial Internet of Things (IIoT). By means of our patented telegram splitting technique, sensor data is transmitted in an energy-efficient, robust and reliable way even over long distances of several kilometers.

With the present standard by the European Telecommunications Standards Institute (ETSI), an association of independent research and development companies and industrial members, an important foundation was laid for the use of so-called low-power wide-area networks (LPWANs). The new ETSI standard guarantees users a generally recognized basis when developing new services and solutions, so that different systems and services can interact harmoniously with each other. Until now,

there has been no reliable communication method suitable for implementing IoT solutions in the transmission and processing of many thousands of data packets at the same time. In addition, energy efficiency, service life and expandability are decisively important in such communication solutions. Now, the MIOTY® technology completes the “last mile” for the continuous end-to-end digitalization of applications with high requirements and difficult environmental conditions. Initial pilot installations are currently active in the oil & gas industry, in mining and for intensive remote maintenance applications.



DIGITAL PICKING WITH INDUCTIVE NEAR-FIELD POSITIONING

IndLoc system detects objects using magnetic fields

To detect objects in a defined environment such as a storage rack or a goods delivery/collection area, our scientists have developed a solution using inductive near-field positioning. The solution makes it possible to passively locate objects in a defined area/volume precisely and in real time. This is achieved using a current-carrying conductor that encompasses an area of variable size and generates a weak alternating magnetic field in this area. The object to be located carries a small passive coil, similar to an RFID transponder. This “localization coil” generates a secondary magnetic field in the observed volume, which is captured by antennas and evaluated by the IndLoc system.

As a result, it is possible to capture with high precision when an object crosses a boundary and also the position, orientation

and movement of the object to be located, without the need for costly active electronics. This method is useful in the picking or replenishing of goods, where the calculated positioning data can be visualized, further processed or assigned to certain patterns. In this way, for example, previously defined actions such as advice or alarm messages can be triggered.

 www.youtube.com/watch?v=z8zd4mXLPio

4 IndLoc® positioning technology can recognize and locate objects in real time and in three dimensions.

MACHINE LEARNING FOR MOVEMENTS IN VR

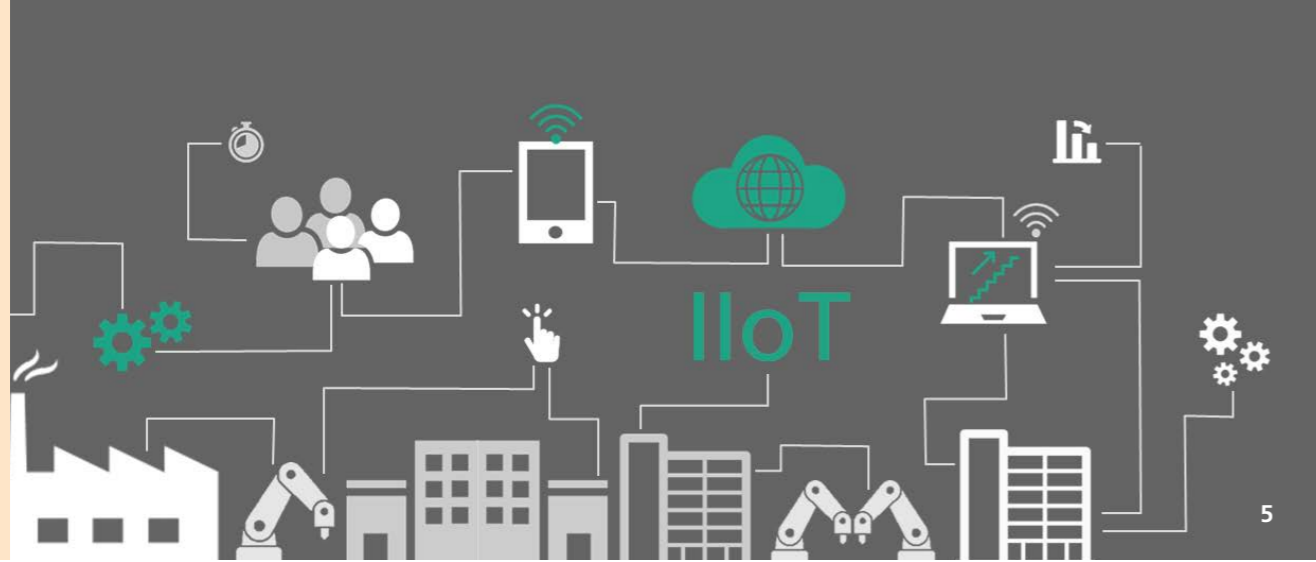
Determining angle of view through movement classification

Virtual reality applications open up a portal to new worlds that are distant in time and space. To do this, various sensors built into VR goggles capture the movements of the user's head and body in space. The cost-effective inertial sensor technology currently used estimates the head orientation of a user relative to a starting or anchor point in the room. With a single sensor, it is not possible to capture the actual angle of view without errors. This makes it important to use a combination of the absolute position and a relative orientation given by the sensor system on the head. The captured raw data is filtered and is used for further feature extraction.

On the basis of this data, an algorithm uses machine learning techniques to classify how movements are directed from head to body. This type of movement classification avoids

positioning errors through early recognition and the correction of large deviations compared to the expected result.

Next, we translate this automatic, intelligent and data-based relationship between head and body movements and the calculated movement trajectory into the correct direction of view. All the while, the evaluation of the orientation of body parts is continuously repeated and improved. The algorithm learns to adapt predictively to successive movements, so that the correct direction of view and a pleasant picture for the user can be fed into the VR goggles.



5

SMART OBJECTS IN MANUFACTURING

In the R2D Road to Digital Production research project, smart objects control processes

A trend for many manufacturing companies is the increasing customization of production. For manufacturing processes down to a batch size of one, production and supplementary parts must be available in the right quantity, in the right place and at the right time for assembly. Particularly for complex work processes in assembly, a whole range of information is required about the workpieces and how to fit them, along with further process and product data.

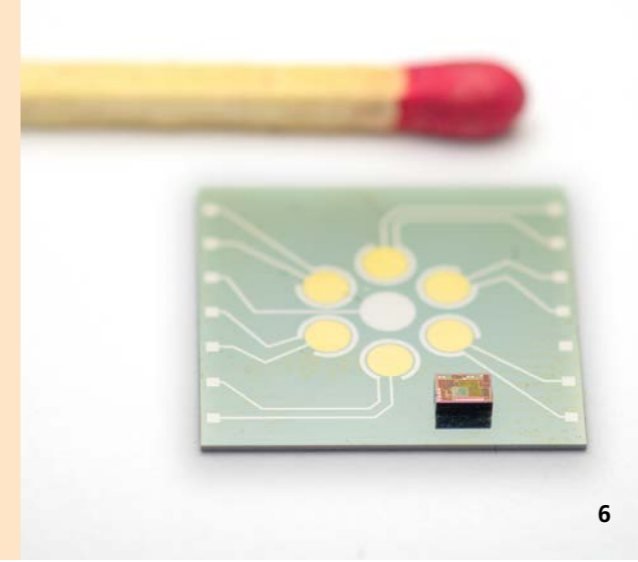
In the R2D Road to Digital Production research project for the digitalization of industrial manufacturing, we demonstrate how so-called smart objects can control and monitor the production process through decentralized decision-making. Workpieces are fitted with electronic tags that possess communication and positioning capabilities. These smart objects are integrated into a communication network. Using the individual data supplied with the product and the contextual information acquired through localization and sensors, the smart workpiece is able to autonomously recognize and log process steps and control production for small batch sizes.

This means, for example, that job data is stored on the electronic tag right at the start of the production process. By virtue of the positioning technology, the tag recognizes when it enters individual manufacturing cells, establishes contact with the tools (e.g. screwdrivers) and systems available there and exchanges product information and other data with them. In this way, the worker can be informed directly which components and small parts to fit. The information is delivered using a pick-by-local-light system, which the smart workpiece can actuate directly. In addition, the smart workpiece can communicate a job order to a smart screwdriver. The smart screwdriver monitors the work steps for the job and shares the job status with both the worker and the electronic tag.

In the R2D project, which is funded by the Bavarian Ministry of Economic Affairs as part of the "Bayern Digital" initiative, these and other technologies are being developed and tested by Fraunhofer IIS, Fraunhofer SCS and various companies under the project leadership of Siemens AG.

 www.iis.fraunhofer.de/smart-object-en

5 Smart objects for IoT applications.



6

DETECTING CHEMICAL SUBSTANCES IN WASTE WATER

Autonomous mini-detectors to discover contaminants

With the production and consumption of synthetic drugs steadily rising, it is vitally important to detect illegal drug laboratories. In the MICROMOLE project, we are collaborating with ten European partners to develop an autonomous monitoring system that recognizes the tiniest amounts of certain chemical substances in sewage. Moreover, it does this with maximum sensitivity and selectivity. This will make it possible, for example, to establish that synthetic drugs are being manufactured in a certain area through the detection of specific substances. Such a control system can also be used in many other domains, such as in water quality assessment.

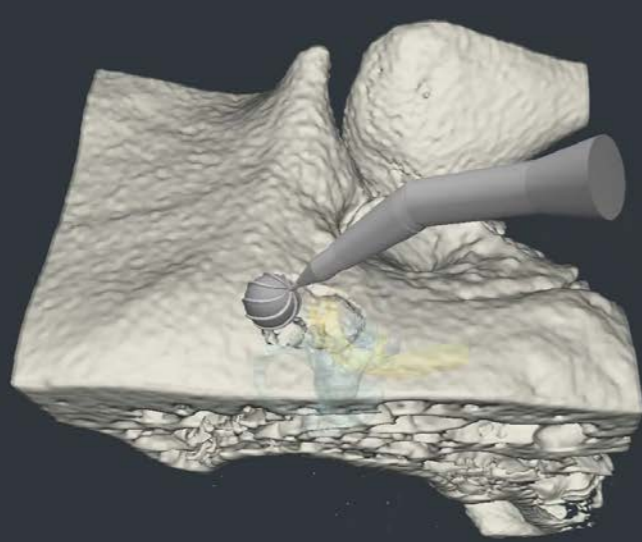
The goal is to reduce the entire system down to the size of a hand, making it possible to detect contaminants in waste water without human intervention. This would render the system suitable for mobile use and for applications such as autonomous and cost-effective on-site analyses to detect impurities in waste water. The main component of the monitoring system is a chemical sensor that is very compact thanks to the microfluidics technology used; a special electrode array makes it robust against changes in water characteristics. By virtue of its extremely high sensitivity, the sensor can detect chemical substances even in very low concentrations in the micromole range.

To achieve this, Fraunhofer IIS developed optimized integrated electronics that allow the highest possible sensor accuracy to be obtained. For maximum performance and reliability, the operating point of the sensor needs to be set precisely. The sensor's output signal must first be amplified, filtered and digitalized before digital signal processing can be used to determine the concentration of the substance to be detected. In addition to high measurement accuracy, another prerequisite for an autonomously functioning sensor system is extremely low energy consumption. To this end, we developed an optimized battery module that delivers energy in sufficient quantities while requiring almost zero maintenance.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 653626.

 www.iis.fraunhofer.de/micromole-en

6 The main component of the system is a miniaturized chemical sensor.



7

VIRTUAL PRACTICE FOR SURGICAL PROCEDURES

“HandsOn.surgery” offers surgeons virtual practice for a specific operation prior to surgery

Surgeons carry out very complex operations on bony tissue, such as cochlear implants in patients with damaged inner ears. To avoid causing injuries to delicate structures such as nerves or blood vessels and to make the surgery as gentle as possible, surgeons need comprehensive theoretical and practical education and specialist training together with many years of experience. To date, training opportunities have been limited to just a few specialized centers in Germany, making widescale training for operations impossible.

In the HaptiVisT project, we support the advanced training of surgeons through the development of a haptic-visual learning system for surgical procedures that can be used in both urban and rural hospitals to address the widespread shortage of medical specialists. Out of this project, the “HandsOn.surgery” virtual operation trainer was born. The virtual trainer supports physicians in their education and training and is designed to help minimize surgery time and the risk of injury.

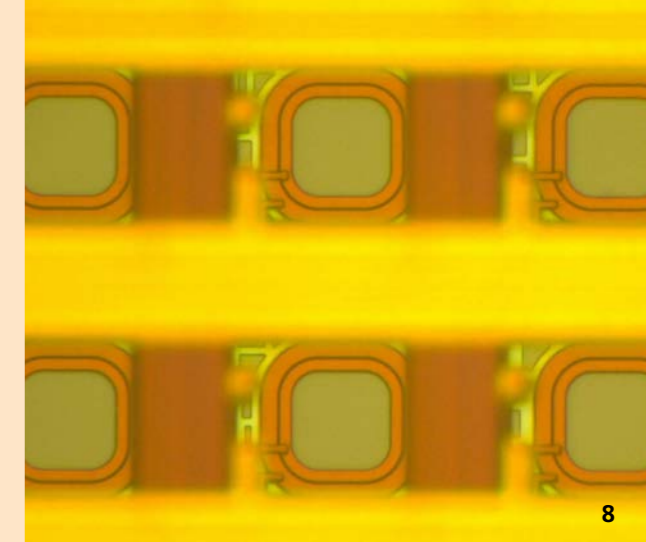
With HandsOn.surgery, surgeons can practice individual procedures in oral and maxillofacial surgery, orthopedics and other areas before the actual operation using the patient’s digital twin – at any time, as often as they want, and with no risk. The surgery trainer enables doctors to see, feel and practice a virtual operation: Because it uses real CT patient data, force feedback from the surgical instrument, intuitive touchscreen selection and a 3D monitor or VR headset, the trainer lets doctors experience the operation as if they were performing it live on the patient, including original operating room sounds.

In the further course of the HaptiVisT project, the demonstrator is now due to be embedded in the educational concepts of our partners and will be evaluated at the 2019 HNO Congress in Berlin.

This project is funded by the German Federal Ministry of Education and Research (BMBF) from June 1, 2016, to May 31, 2019, (Grant: 16SV7559).

 www.iis.fraunhofer.de/en/handson

7 “HandsOn.surgery” trainer: virtual bone with risk structures and surgical instrument.



8

NETWORK FOR INNOVATION IN MEDICINE

In the EU’s “EIT Health” program, we coordinate network activities for twelve Fraunhofer institutes

The Knowledge and Innovation Communities (KICs) of the current European Union HORIZON 2020 framework program offer the opportunity to network with excellent European partners and contribute to the accelerated development of innovations in Europe.

In “EIT Health” – one of six KICs that have been set up – which has been responsible for all developments by the European Institute of Innovation & Technology (EIT) in the subject area of medicine and health since 2015, the Fraunhofer-Gesellschaft was initially able to cooperate only through us as an associated partner. Later, Fraunhofer was able to take up a core partnership as of 2018, the responsibility for which is currently shared by twelve Fraunhofer institutes under the coordination of Fraunhofer IIS. This opens

up a variety of opportunities for the Fraunhofer-Gesellschaft and the institutes involved to directly shape and influence the community and establish easy contact with currently over 140 national and international partners. At present, we are working on the EIT Health project “movelt”: In collaboration with the Friedrich-Alexander-Universität Erlangen-Nürnberg and the Universitätsklinikum Erlangen, and with Philips AG as the industrial partner, we are developing innovative new techniques for the diagnosis and treatment of Parkinson’s patients.

 www.eithealth.eu

IMAGE SENSORS FOR MONITORING OF VEHICLE ENVIRONMENT

3D mapping of surroundings for use in autonomous driving and mobile robotics

LiDAR (light detection and ranging) technology is often used in sensors for distance measurement and environmental recognition. Sensors can use LiDAR to measure the distance to an object, and to a certain extent its velocity, all in real time. Instead of radio waves, light is used for detection, which permits higher resolution in the 3D recording of the environment, including the movement of people or cars.

individual photons hit a sensor and trigger an avalanche of electrons. Because this makes individual photons detectable, it enables optical time-of-flight measurement. From this time of flight, the distance to an object is then calculated directly.

 www.iis.fraunhofer.de/opticalsensors

For each application, we develop customized image sensors, including time-of-flight (ToF) image sensors for optical distance measurement, which can determine the position of objects with high precision. This involves detecting when an emitted pulse of light returns to a receiver after reflecting off an object (optical time-of-flight measurement). This is achieved using single-photon avalanche diode (SPAD) arrays, in which

8 Single-photon detection measures when an object reflects and sends back an emitted pulse of light.

DIGITALIZATION IN RURAL AREAS

Rural areas in Germany are faced with a series of challenges on account of the current demographic changes. Digitalization offers a great deal of potential for preserving public services and turning rural areas back into more attractive places to live and work. Consequently, in an interdisciplinary team, we develop and investigate new digital solutions in meeting household needs, medicine and nursing care, education, and mobility, all of which affect quality of life.

Germany consists largely of "rural areas"; in 2015, roughly 18 million people lived in districts classified as "rural." However, the majority of rural areas currently face a series of challenges: Low population density and forecast population decreases make commercial ventures unprofitable and make it harder to run public services. In turn, this makes life in the country increasingly less attractive for rural residents.

Everyone agrees that this trend must be stopped. One possibility for bringing public services and innovative commercial service offers closer to rural areas, and thus making them more attractive again as places to work and live, is digitalization. The preconditions for digitalizing rural areas are currently being created: over 90 percent of rural households now have a broadband connection of 6 Mbit/sec or faster; about two-thirds have 16 Mbit/sec or faster; and about one-third have 50 Mbit/sec or faster.

Digitalization offers the opportunity to prevent the withdrawal of public services from a region by offering them in a digital form or to improve the quality of existing services.

AT A GLANCE

- 1 | Broadband availability is being continuously expanded and optimized – also in the country.
- 2 | Digitalization holds great potential for preserving and improving public services in rural areas.
- 3 | Digitalization projects call for an interdisciplinary approach.

1 *Digital Village: A digital solution for the local supply of everyday goods is the Mobile Village Store by the Steinwald-Allianz community association. The central element of the concept is a digital platform connecting the customers, vendors and producers of regional goods.*



1
Products from
the region

2
Order
online

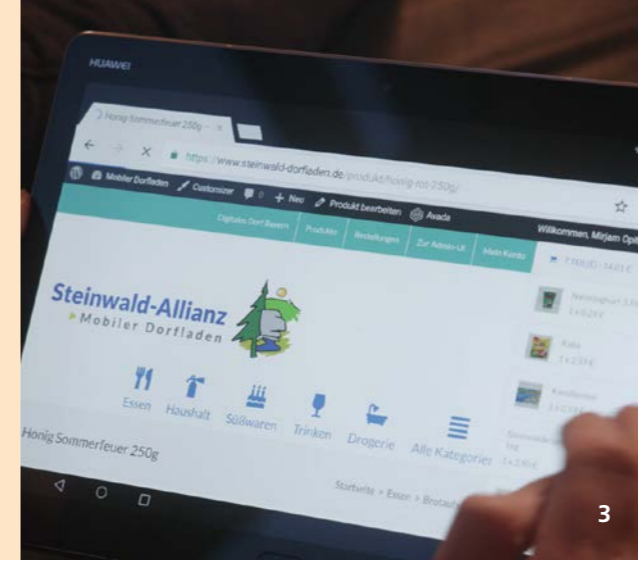


3
Collect here

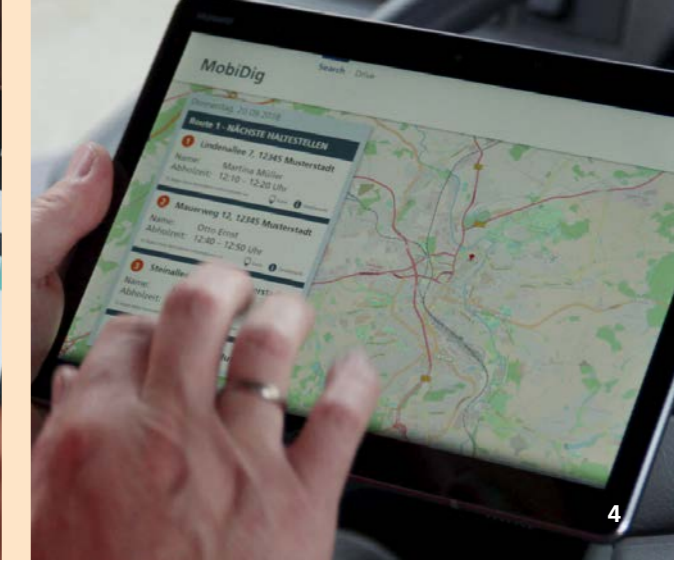




2



3



4

To date, however, municipalities have shown little inclination to engage with these possibilities – often the people responsible know too little about the benefits and the areas in which digitalization can be used. To address this situation, we investigate and illustrate the potential of digitalization for individual areas of life in a series of research projects.

Local supply of regional products

One of the biggest challenges in rural areas is maintaining the supply of food. Residents must increasingly travel long distances to the nearest supermarket, because small stores in rural centers are closing down, while big supermarkets open only in areas with large populations or out of town. As part of the “Digital Village” project, we joined forces with the Fraunhofer Institute for Experimental Software Engineering IESE and the Steinwald-Allianz, an interest group comprising 16 local communities in the rural district of Tirschenreuth in Germany, to create a “Mobile Village Store” designed to maintain the local supply of everyday goods. The central element of the concept is a digital platform connecting the customers, vendors and producers of regional goods. In order to strengthen regional economies, the products of regional producers are given priority.

“A MORE EFFICIENT EXCHANGE SHOULD BE FACILITATED BETWEEN HOME CARE NURSING SERVICES, DOCTORS AND PATIENTS IN THEIR HOMES.”

Improving health care through connectivity

Telemedicine and telecare services can help preserve health care in rural areas at a time when there are shortages of doctors and carers. The use of telemedicine and telecare is not intended to replace regular services completely. However, digitally supported services are faster and more cost effective to access and are independent of the mobility of patients and professional staff. In the “Digital Health Village Oberes Rodachtal” project, we are researching integrated connectivity between citizens and the providers of health and nursing care in the rural district of Kronach in Germany. A digital platform is set to facilitate a more efficient exchange between home care nursing services, doctors and patients in their homes.

Digital skills for increased participation

An important prerequisite for the use of digital services is the Internet and digital skills of citizens. In 2017, 81 percent of the German population was online, but there were large discrepancies ac-

ording to age and level of education. In the “Digital Village: Living and Educating” project, we are cooperating with the rural district of Tirschenreuth in Germany to develop comprehensive further education offerings on the topic of digitalization. These offerings are aimed primarily at older people with various degrees of background experience. The focus is on casual learning approaches, such as senior centers, volunteer instructors and buddy-type exchanges between young and old, as these non-intimidating methods have proved particularly promising.

Efficient and demand-centered local public transport



Turning our attention to mobility, digital solutions can help strengthen connectivity between different modes of transport and thus supplement the frequently depleted local public transport services in rural areas. In the “Digital Mobility Upper Franconia” project, we are working with Hof University of Applied Sciences, the Technical University of Munich, the rural district of Wunsiedel and the municipal government of Hof to develop an innovative mobility concept for rural areas. Drawing on regionally available data such as timetables, school calendars, weather data and event dates, forecasts are made for mobility demand so public transport services can be tailored to actual demand. In addition, the project partners are developing ideas to integrate concepts such as car or bike sharing or self-driving buses into local mobility offerings.

These projects involve several disciplines work together. Digitalization projects draw on IT expertise and various branches of engineering; mathematics researchers are involved at the data analysis end of things; business experts work on improving processes and business models; and academics from the social sciences investigate individual and social influencing factors. ■

2 Digital Village: The Mobile Village Store connects approx. 30 rural areas, 4000 citizens and 20 producers as a sort of “mobile supermarket” for the Steinwald-Allianz community association.

3 Digital Village: In the online store, residents involved in the Steinwald-Allianz can order around 200 products, which are then delivered by the Mobile Village Store.

4 Digital Mobility Upper Franconia: An innovative mobility concept provides better transport connectivity in rural areas based on digital solutions.

 
www.scs.fraunhofer.de/
digitales-dorf



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DATA ANALYTICS IN THE SUPPLY CHAIN

Forecasting demand for spare parts with supply chain analytics

Data analytics offers a wide range of possibilities for optimizing applications in logistics. In addition to optimizing logistics networks or identifying KPIs, it holds huge potential for the prediction of critical events such as delays, customer demand and required stock levels. The question of which applications actually warrant the use of descriptive, predictive or prescriptive data analytics methods, and what data is needed in the first place, varies from case to case. The actual cost and benefit for companies becomes clear only during the concrete analytics use case.

For example, we worked with a manufacturer of domestic appliances to analyze its master and consumption data specifically for patterns and similarities. Using machine learning, a model was developed from this analysis for the long-term

forecasting of the expected demand for spare parts. On this basis, the customer's dispatchers can now plan and utilize their stock levels in an optimal manner.

We have built up a library with analytics use cases and linked them with useful context such as information about the corresponding business processes and the data required for them. This enables companies to quickly find applications that are interesting for them, transfer these applications to their own business processes and evaluate them, and initialize analytics projects.

 www.scs.fraunhofer.de/supplychainanalytics

NEW PLATFORM FOR LOGISTICS REAL ESTATE

"L.Immo online" offers up-to-date market and site data for Germany's 23 logistics regions

The construction and further development of logistics centers and buildings is a commercially and financially attractive proposition for users, investors, project developers and municipal governments – provided that the conditions are right. Accordingly, for over ten years, we have been analyzing and evaluating the general conditions in Germany in a scientifically grounded way and making the results available to customers.

In 2018, the contents of the "Logistics Real Estate – Market and Sites" series of studies, which are published every two years, were transferred to an online platform called "L.Immo online." The centerpiece is an interactive map with individually selectable elements that not only display attractiveness and intensity ratings, but also show the individual logistics real estate sites along with their age and user structure in Germany's

23 logistics regions. In a view provided free of charge, users can obtain an overview of German logistics regions and the methodology used; regional or full-access options allow users to explore the individual regions in greater detail.

The platform offers all market players a basis for investment decisions, site evaluations and real estate valuations. The new online format also makes it possible to update the data twice a year, to display all contents in English at the click of a button, or to add new features and evaluation options depending on market developments.

 www.limmo-online.de



ADA CENTER: ARTIFICIAL INTELLIGENCE IN OPERATION

The ADA Center for Analytics, Data and Applications combines AI research with industrial applications

Data is the raw material of the digital world. That being so, it is essential for companies to master, analyze and evaluate data if they are to remain competitive. However, the more data that arises, the more important it becomes to handle it efficiently. This is where artificial intelligence (AI) techniques such as machine learning and mathematical optimization can help – but these in turn require a specific expertise that is not readily available in many companies. So how can this knowledge be made accessible for industry? Through a center of excellence that networks science and industry.

To achieve this, we teamed up with the Friedrich-Alexander Universität Erlangen-Nürnberg and the Ludwig-Maximilians-Universität München to create a unique research infrastructure in Bavaria: the ADA Center for Analytics, Data and Applications.

This is an exciting venue where companies can come into contact with leading national and international AI researchers to work together on specific projects. This promotes the creation of practical new data analytics techniques and algorithms in specific applications within a very short period – with corresponding added value for industry, services and research.

The focus in the ADA Center is on applications in the domains of manufacturing, mobility, logistics and health, such as data-driven localization, verifiable AI for the medical and automotive industries, logistics ecosystems, and driver assistance systems for rail transportation. The personnel at the ADA Center carries out research into nine fields of artificial intelligence, including learning with less annotated data, explainable AI and mathematical optimization techniques.

If new things are to be created, then new things must be tried out. As such, the ADA Center employs innovative forms of cooperation and infrastructure, such as joint labs for agile project development on a temporary basis, a data analytics showroom as an AI world of experience, and the ADA "Young Talents" hub for supporting and nurturing highly qualified new talent for careers in science and business. The project is funded by the Bavarian Ministry of Economic Affairs.

 www.ada-center.de



X-RAYS FROM ANYWHERE

Industrial computed tomography (CT) has become a fixture of the modern industrial environment and is used in various sectors. Many companies now utilize several CT systems for a wide variety of tasks, from the monitoring of production processes and the sorting of objects to completeness analysis. So that companies can work efficiently with such proliferating masses of machinery, Fraunhofer IIS has developed a new data management software.

“CloudCT” significantly improves the user friendliness of CT and makes it easier to handle the resulting data volumes. The software saves all data centrally in the company’s own cloud, so users can access it from any device.

In particular, large operations running several CT systems were lacking a practical means before now that would enable them to save and access CT data centrally. In addition, users could not view data when on the move. CloudCT is a web-based CT data management system that solves this problem by enabling users to save and visualize various kinds of data that are generated and managed in the industrial CT environment. This includes information such as projection data, volume data and metadata. Now, users can access CT data from anywhere – for example, during a meeting with a client. But that is not all: CloudCT also allows users to monitor the progress of ongoing measurements and to restart them if a problem should arise.

The development of CloudCT was undertaken initially for internal reasons: “At Fraunhofer EZRT, we operate numerous X-ray systems. Because they’re situated in different rooms and even buildings, we wanted a system that would give us access to our CT data from anywhere,”

AT A GLANCE

- 1 | CloudCT is a web-based data management system for handling CT data.
- 2 | Access to CloudCT is possible from any kind of device without having to install special software.
- 3 | CloudCT can be adapted to different CT machines and systems.

explains Thomas Miller, computer scientist at the Fraunhofer Development Center for X-ray Technology EZRT.

Accessing CT data from any device

Any kind of device can access CloudCT from a regular browser, without having to install additional programs. CloudCT archives all CT data in a standardized format and offers the option of being able to view and edit this data from any computer. Consequently, users are no longer tied to specific computers. This increases the user friendliness of industrial CT and gives a major boost to efficiency. Because the data is no longer distributed across several media, database inconsistencies are a thing of the past. Users no longer have to organize their data stock, as CloudCT does it automatically for them. A search function lets users quickly and conveniently filter data by a series of search criteria, such as name, date or various keywords. In addition, a central RAID system increases data security.

Users can integrate a virtually unlimited number of CT scanners into the CloudCT software and call up real-time information about all scans that are in progress, such as name of the measurement, the start time and the remaining measurement time. Moreover, the results of CT measurements – projection and volume data for example – are automatically transmitted to the system. As such, they are available to the user immediately. The CT scanners can be fitted with sensors and connected to CloudCT via a standardized interface. These sensors transmit condition information such as humidity, temperature and air pressure.

Flexibility for all users

Companies often operate several CT systems, which can come from different manufacturers and have their own system software. This is why CloudCT was developed so that it could be utilized flexibly by all users. “We held in-depth discussions with various CT manufacturers so we could adapt the CloudCT system to different systems,” Miller explains. CloudCT usually takes no longer than a day to install. The exact amount of time depends on the systems and databases to which CloudCT has to be adapted. However, the time invested in setting up the system is swiftly recovered, as the use of CloudCT permits huge time savings. The CloudCT system is being continuously developed further. In the future, an app will enable convenient access to the system via smartphones and tablet computers. Push notifications will deliver real-time information to users, such as for the case that a measurement is completed or an error has occurred..

The online processing of image data will also be expanded in the future: new algorithms will be available to be used on the data directly, such as reconstruction algorithms or algorithms

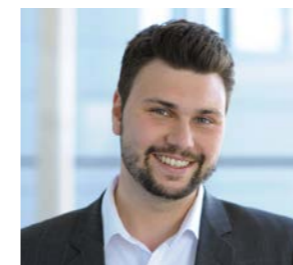
“USERS CAN CALL UP REAL-TIME INFORMATION ABOUT ALL SCANS THAT ARE IN PROGRESS.”

for metrological evaluation. Via a statistics module, it will be possible in the future to call up a wide range of statistics about the connected CTs, such as capacity utilization and outage times. In addition, automatic data compression will ensure efficient handling of the large amounts of data.

“CloudCT is a piece of software, and its development is far from finished with the latest version,” Miller says. “The fact that we are using the software in our own labs is a tremendous help.” Through these ongoing developments, the CloudCT system will further increase the efficiency and user friendliness of industrial computed tomography and thus improve the cost effectiveness of this technology even more. ■



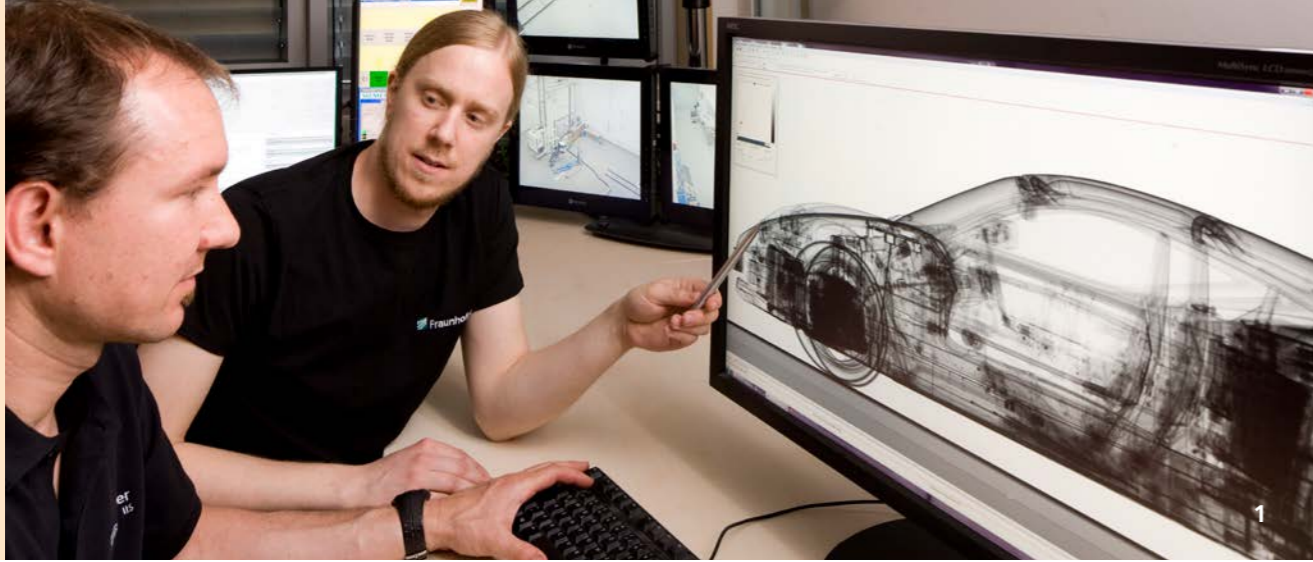
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cloudct-en](http://www.iis.fraunhofer.de/cloudct-en)



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AWARD-WINNING XXL COMPUTED TOMOGRAPHY



Joseph von Fraunhofer Prize 2018 for X-ray analysis in a new dimension

Our researchers have developed a computed tomography (CT) system that analyzes very large objects, such as freight containers, by applying X-rays and generates high-resolution, three-dimensional images. For a long time, due to the limited power of X-ray tube assemblies, CT was restricted to smaller objects that were easy to penetrate by X-rays. Michael Salamon, Nils Reims and Dr. Michael Böhnel managed to overcome these restrictions. They were awarded the 2018 Joseph von Fraunhofer Prize for the work they carried out at our Development Center for X-ray Technology on the subject of XXL computed tomography. This made it the sixth time in a row our institute has won the prize.

CT with X-rays plays a major role in industrial product development. The objects are rotated on a heavy-duty turntable. A detector and an X-ray source are scanning the object synchronously in vertical movements line by line. Through the rotation of the turntable, the sensor acquires images of the object from many angles, creating the basis for a 3D representation.

Before now, however, such CT scanning – particularly in the high-energy range – was restricted to smaller, simple objects due to a lack of suitable reconstruction and corrective algorithms and sensors. Objects had to be laboriously dismantled before their structure and inner workings could be analyzed. Thanks to non-destructive X-ray testing, it is now possible to analyze in detail the structure and materials of previously unscannable objects.

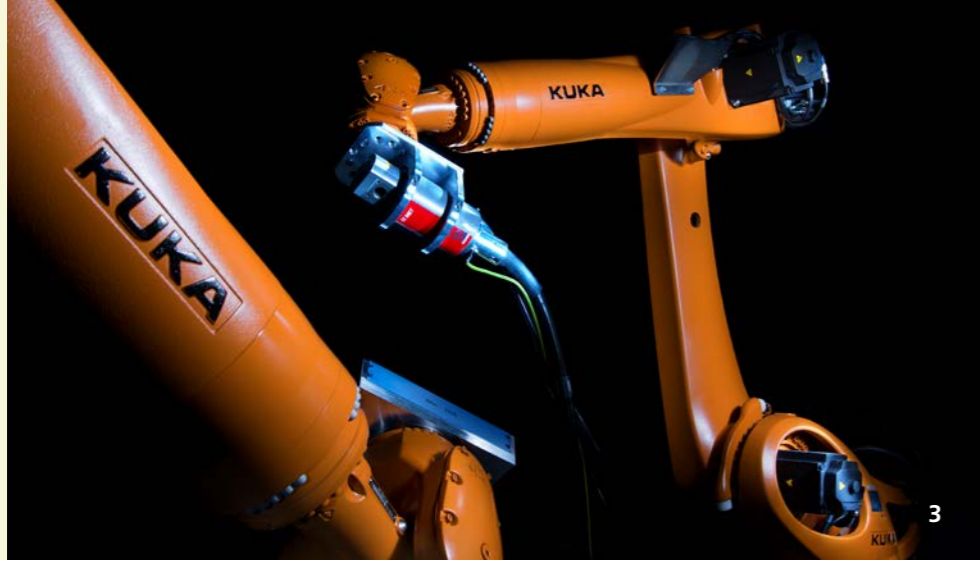
For the first time, objects with a diameter of 3.20 meters and a height of 5 meters can be analyzed by X-rays – and a special technique that records a large object in several sections permits the scanning of even larger objects. This makes our apparatus one of the largest CT systems in the world at present. Uses for XXL CT include analyzing electric cars after a crash test and inspecting freight containers. Meanwhile, the results achieved by the system have garnered worldwide attention and recognition in the domains of product development and quality assurance and also in the digitalization of historical artifacts.

  www.iis.fraunhofer.de/jvf-preis-en

1 For the first time, objects with a diameter of 3.20 meters and a height of 5 meters can be analyzed by X-rays.

2 Dr. Michael Böhnel, Nils Reims and Michael Salamon (from left to right) received the Joseph von Fraunhofer Prize 2018 for the development of XXL computed tomography.





3

COMMISSIONING OF FIRST ROBOT-BASED CT SYSTEM

“RoboCT” analyzes the quality of vehicles in automotive production without disassembly

In cooperation with the BMW Group, the Fraunhofer Development Center for X-ray Technology EZRT has developed a robot-assisted computed tomography system that, unlike conventional CT systems, reaches inspection positions on objects with complex shapes, such as a car body.

Around 13 years of development work went into this technology, financed both by publicly funded and by independent research projects. It was originally developed especially for aerospace testing, for example to inspect entire wings for defects. In close cooperation with engineers from the BMW Group at the Research and Innovation Centre (FIZ) in Munich, the CT system was installed directly at the interface between development and production, and was put into operation in July 2018.

In the setup there, four cooperating robots travel around the vehicle and move the imaging components, such as the X-ray source and detector, correspondingly. This allows RoboCT to access practically all positions on the vehicle. The system is capable of recording three-dimensional CT data down to a scale of approx. 100 micrometers. With this technology, objects can be analyzed in detail with extreme precision and without damaging them. Until now, performing this level of analysis required the relevant components to be disassembled and analyzed in a separate CT system.

The robot-assisted CT in its current form as brought about by these developments is just the beginning of a larger idea: in the long term, so-called cognitive sensor systems will exclusively acquire relevant data. Moreover, the cognitive sensor system itself will determine which data is relevant. This will provide customers with a monitoring system that helps them optimize their processes. It should be specified here that the word “process” does not refer only to the traditional manufacturing process, but also to processes in materials development, construction, maintenance, commerce and recycling. And it is also in this direction that Fraunhofer EZRT is shifting the focus of its research activities.

3 A RoboCT setup with the X-ray source and detector used for imaging.



4

“WE’LL ALSO BE COOPERATING CLOSELY IN THE FUTURE.”

Interview with Dr. Stefan Kerscher from the BMW Group

Dr. Kerscher, in July 2018 you put Fraunhofer EZRT’s RoboCT system into operation at the Research and Innovation Centre (FIZ) in Munich, at the interface between development and production. How exactly are you benefiting from RoboCT?

As of now, this new technology enables us to make X-ray and CT scans from the sections of a complete car body or even of a whole vehicle. This means we can carry out scans at selected joints and junctures, for example, and analyze them in detail. Previously, we had to dismantle the car body into individual components in order to expose the relevant sections for a stationary CT. The advantage of the nondestructive testing is the comparatively high speed with which we can scan our vehicles. On top of this, it lets us keep the car body and subsequently use it for further tests and investigations. Furthermore, the system allows us to respond flexibly to issues in the various development phases of a vehicle and to use nondestructive testing for individual tests. When investigating vehicle structures as part of crash testing, we’re now also able to X-ray individual sections in detail. Currently we’re exploring application of the technology in further areas of vehicle development and production.



5

What does the cooperation between the BMW Group and Fraunhofer EZRT look like at an everyday level?

In the area of computed tomography, we’ve built up a stable and efficient working collaboration with Fraunhofer EZRT over the past few years. We’ll also be cooperating closely in the future, and among other goals we’ll be pushing forward with the further development of the technology in relation to the automation of processes.

Dr. Kerscher, thank you very much for your time.

You can find further examples of cooperation with us in the Fraunhofer IIS Magazine:

 www.iis.fraunhofer.de/magazine

4 RoboCT is able to reach inspection positions on objects with complex shapes, such as a car body.

5 Dr. Stefan Kerscher, Head of Non-Metallic Parts, Materials and Process Analytics Technology, BMW Group.

FRAUNHOFER IIS – YOUR PARTNER

Outstanding ideas. Research with a strong practical focus.
Cooperation founded on trust.

Fraunhofer IIS is a partner for customers from industry and public institutions. We develop, implement and optimize techniques, products and systems until they are ready for use and market launch. By virtue of the flexible networking of expertise, skills and capacities in the institute, we are also able to meet extensive project requirements and create complex system solutions.

Market studies – Knowledge for innovations

In advance of a research collaboration, we advise you in the form of customized studies, market observations, trend analyses and profitability calculations.

Consulting and project support

You can hire our consulting services for advice on technological questions, on improving individual work processes or on the entire development of a product. We draw up recommendations for action for your investment decisions. Moreover, we support you in the implementation of new technologies and help you successfully realize your applications.

Research on demand

Industrial companies and service providers of all sizes benefit from contract research, and we are happy to pass on our know-how. For our customers in companies, we develop and optimize technologies, methods and products and even manufacture prototypes.

Licensing technologies and systems

We make the results of our research work available to industry in the form of patents or licenses.



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RESEARCH FAB MICROELECTRONICS GERMANY

Coordinated German technology know-how from a single source

The Fraunhofer Institute for Integrated Circuits IIS is one of the member institutes of the Fraunhofer Group for Microelectronics and is therefore part of the Research Fab Microelectronics Germany (FMD). With over 2000 scientists, this research network is the largest cross-organizational R&D association for micro- and nanoelectronics in Europe.

Strengthening Germany and Europe as cradles of innovation

The German Federal Ministry of Education and Research (BMBF) is funding the establishment of FMD with a total of 350 million euros, which represents its largest investment in research facilities since German reunification. This will provide a unique resource for the semiconductor and electronics industries in Germany and Europe, which will see their innovation capabilities boosted in global competition thanks to FMD.

In a first step, since the project launched on April 6, 2017, the outstanding know-how of the participating institutes has already been supplemented by modern laboratory lines and further leading-edge research equipment. The commissioning of a first integration line took place on September 28, 2018 as part of the inaugural FMD Innovation Day by proxy at the Fraunhofer Institute for Reliability and Microintegration IZM in Berlin.

Promoting commercially important technologies at Fraunhofer IIS

With respect to Fraunhofer IIS, 35.2 million euros are being invested in the institute's sites at Dresden, Erlangen, Fürth, Ilmenau and Nuremberg. Fraunhofer IIS's principal technological priority areas and contributions to FMD will be in the domains of information and communications technology, power electronics, circuit design, sensor systems, materials research and reliability studies. These will address the commercially important application areas of energy technology, automotive, aerospace, Industrie 4.0 and digitalization.

In 2019, the Research Fab Microelectronics Germany will enter its next phase. After the setup stage, FMD will be offering industrial partners a forward-looking portfolio of technological developments and services along the full length of the value chain, based on the advanced research facilities at the participating institutes.

IN BRIEF



1



2

In April 2018, we hosted the finals of the EMEA NXP Cup. And at our research campus in Waischenfeld, a summer school was held for the first time. We have compiled a small selection of brief news items for you over the following pages.

Overview of selected stories:

- #inNUEvati – Taking the „NO“ out of innovation
- Researching data transmission during the vacation
- Self-driving model cars
- Big picture
- Urban and rural connectivity

#INNUEVATION – „TAKING THE „NO“ OUT OF INNOVATION“

The Leistungszentrum Elektroniksysteme (LZE) hosted the #inNUEvati innovation conference.

At the conference, guests from research, business and politics engaged intensively with the topic of innovations from various perspectives. The conference itself was also an innovation by the Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU) and the two Fraunhofer Institutes IIS and IISB, which jointly developed this format for the first time on the LZE platform. For two days, international guests from places including Bangalore, Cambridge, Exeter, Stanford and Paris joined high-ranking representatives from the world of industry to exchange ideas and viewpoints on the topics of digitalization and innovation research, and in particular the future technologies of artificial intelligence and 5G. The keynote was delivered by Prof. Dieter Kempf, President of the Federation of German Industries (BDI). In addition, there was an official delegation from Taiwan, with

whom we laid the groundwork for an international collaboration in the context of the JOSEPHS® innovation laboratory.

The guests agreed that, from a worldwide perspective, the Nuremberg metropolitan area has ideal conditions as a strong innovation region. But it is also about actually realizing this potential – to take the “NO” out of the word inNOvation. The first #inNUEvati conference gave a kick-start to this process.

 www.iis.fraunhofer.de/innuevati-2018-en

1 Bavarian State Minister Franz Josef Pschierer (3rd from left) at the #inNUEvati conference.

RESEARCHING DATA TRANSMISSION DURING THE VACATION

At the MIOTY Summer School, students worked on radio transmission techniques

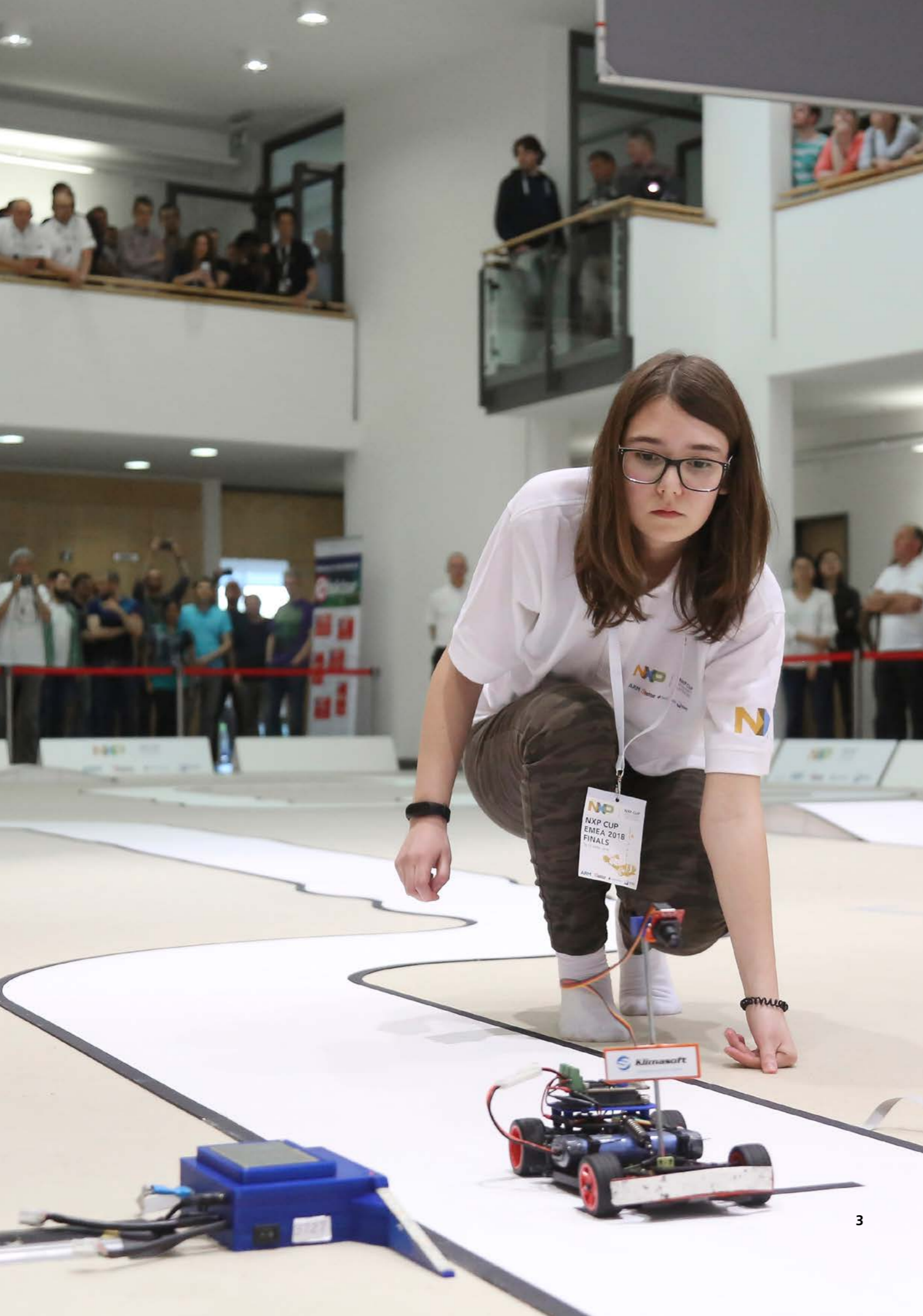
The Internet of Things is one of the megatrends of our time. But what exactly is it? This is what more than 25 students from all over Germany learned at the Summer School on our research campus in the Bavarian town of Waischenfeld.

The topic of the one-week event was radio transmission and specifically the MIOTY™ technology developed by Fraunhofer IIS. This system can transmit data up to 15 kilometers and has a battery lifetime of up to 20 years. Following a technical introduction to the finer details of radio transmission techniques, the participants worked together in project teams. For the project, they received a transmission platform with which they experimented, developed application ideas and implemented them in prototypes. Some of our scientists were on site throughout the week to support the teams. At the end

of the week, the teams presented their results.

Examples of the ideas developed by the students include concepts for monitoring wind turbines for icing and vibrations, concepts for monitoring hospital beds and assisting patient management, and sensors for monitoring precipitation and water levels for applications in environmental and flood protection.

2 At the MIOTY Summer School, students developed prototypes for radio transmission techniques.



3



SELF-DRIVING MODEL CARS

Finals of 2018 NXP Cup for Europe, Middle East and Africa held at Fraunhofer IIS

The NXP Cup is an international competition in which semiconductor manufacturer NXP provides student teams with the latest technology for self-driving cars. This season, more than 110 college and university teams from Europe, the Middle East and Africa (EMEA) registered for the competition. A total of 18 teams from 12 countries qualified for the 2017/2018 EMEA finals at our headquarters in Erlangen.

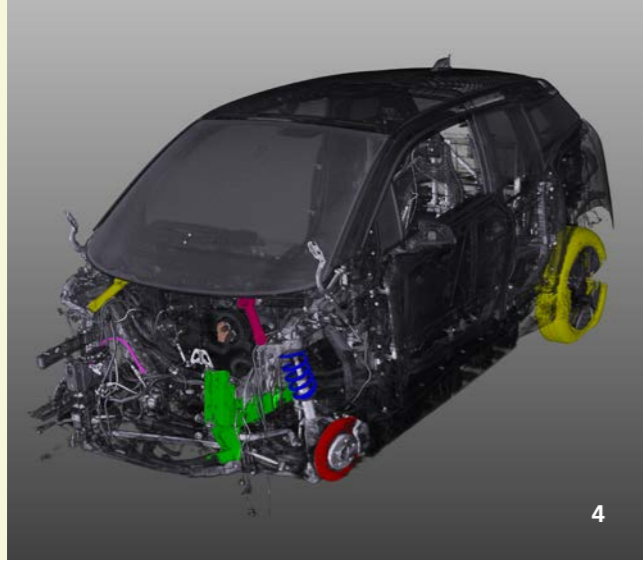
For four months, the students assembled, programmed and tried out their vehicles, which they then tested and fine-tuned in the one-and-a-half days leading up to the decisive race. In training, the model cars had to go around obstacles and swiftly accelerate and brake on a defined track.

The teams sent their model cars into competition in two different model classes. Covering 160 square meters, the racecourse featured bumps in the road, junctions, hills and further obstacles.

The winner of the competition in the "Alamak" model kit category was the "FasTech" team from the University of Craiova in Romania. In second place was the "Athlos" team from the University of West Attica in Greece. And third place was taken by "ACDT" from the Technical University of Iasi in Romania.

In the "Model C" model kit category, the "Koala Racer" team from the University of Applied Sciences Landshut took first place. Second was "The K-Team" from Deggendorf Institute of Technology. And third was the "Mac" team from Mundiapolis University in Morocco.

 www.iis.fraunhofer.de/nxp-cup2018-en



BIG PICTURE

Funding obtained for a project to process huge image files of three-dimensional objects

When seeking to digitalize three-dimensional objects with high precision, so-called “big pictures” are created. These are image data on completely unprecedented scales. These huge data volumes have to be saved, processed and converted into usable information. Our Development Center for X-ray Technology develops intelligent sensor systems that generate such data. The goal is to extract the relevant digital information from a wide variety of nondestructive measurement sensor systems – information that permits control or regulation such as is required in process monitoring. Measuring systems are increasingly generating large and highly complex data volumes that can often no longer be processed using traditional digital image processing. For this reason in particular, a project was initiated to carry out research and development into image processing strategies and operators with new, intelligent approaches that draw on machine and deep learning.

The first fruits of this project are a new kind of compression technique that reduces the data volume to a fraction of what it was with no perceptible loss in quality, and a segmentation technique that learns from user interaction to isolate objects – such as the blue spring in the picture – and find them again in other images.

Funding of 4 million euros has been granted by the Bavarian Ministry of Economic Affairs to the research project being carried out at the Fraunhofer sites in Fürth, Deggendorf and Passau. The contents of the project were designed particularly with the requirements of Bavarian industrial partners in mind.

4 3D data set of a vehicle with segmented components.



URBAN AND RURAL CONNECTIVITY

Funding notification for research in topic areas “City.digital” and “Agriculture.digital”

Currently available technologies are not up to the task of solving the parking situation in cities or optimizing the use of fertilizer in modern agriculture. In February 2018, Bavaria's then Minister of Economic Affairs Ilse Aigner awarded the “FutureIoT” research alliance a funding notification for 2 million euros from the Bavarian Research Foundation to support practically oriented research in the “City.digital” and “Agriculture.digital” topic areas.

The goal of the research alliance, which involves over 30 partners from industry and research, is the joint development of comprehensive Internet of Things (IoT) solutions from sensors to an open IoT platform. Existing urban challenges such as insufficient parking and elevated levels of air pollution will be overcome through the further development and combination of individual technologies in the domains of communications, sensor systems, positioning, information security and IoT platforms. And in agriculture, IoT-supported ground analysis will improve the use of fertilizers, while IoT solutions will also help with livestock management, for instance by allowing animals' health and fertility to be monitored not just in the barn but also in fields and pastures.



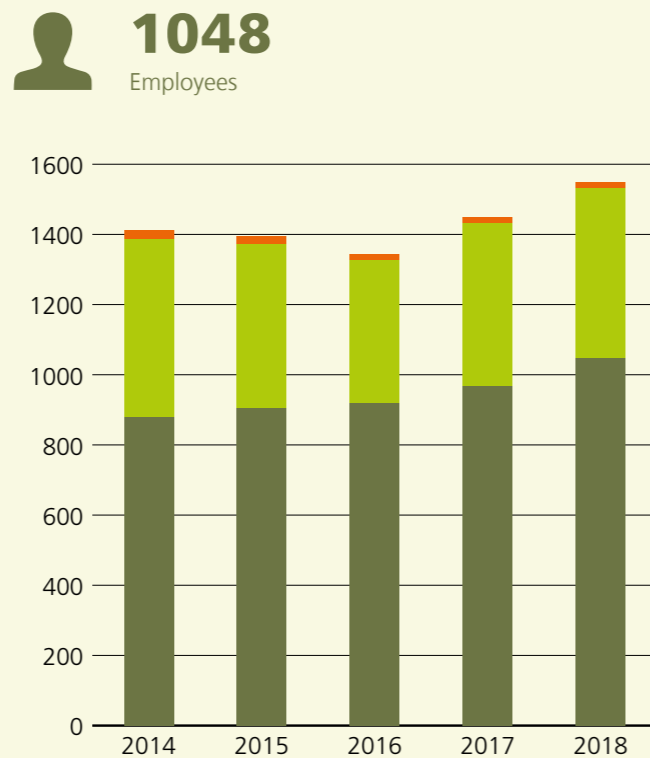
5 At the kick-off event in February 2018, almost 40 partners from industry and research came together to launch the joint FutureIoT project.

FRAUNHOFER IIS IN NUMBERS

More personnel for the technologies of tomorrow

Our employees are the basis for the institute's success. That is why we strive to offer them the best possible working conditions at our institute. This approach pays off: In 2018, the number of employees at Fraunhofer IIS rose again.

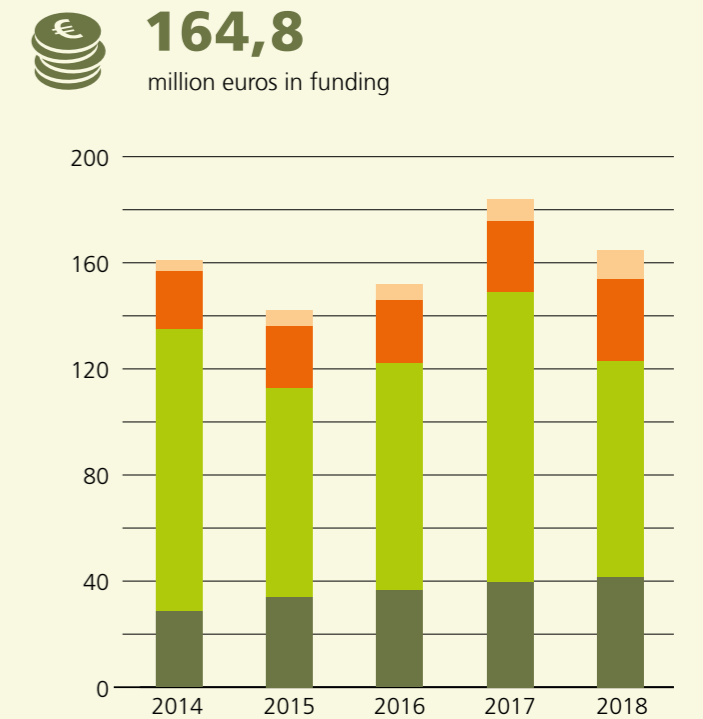
- Permanent employees
- Student assistants
- Trainees



52 percent industrial earnings

In 2018, as in previous years, Fraunhofer IIS had a balanced budget and a positive surplus. 52 percent of its funds came from industry and business. The base funding from the Fraunhofer-Gesellschaft was 26 percent. Meanwhile, 20 percent of the budget came from public-service revenue.

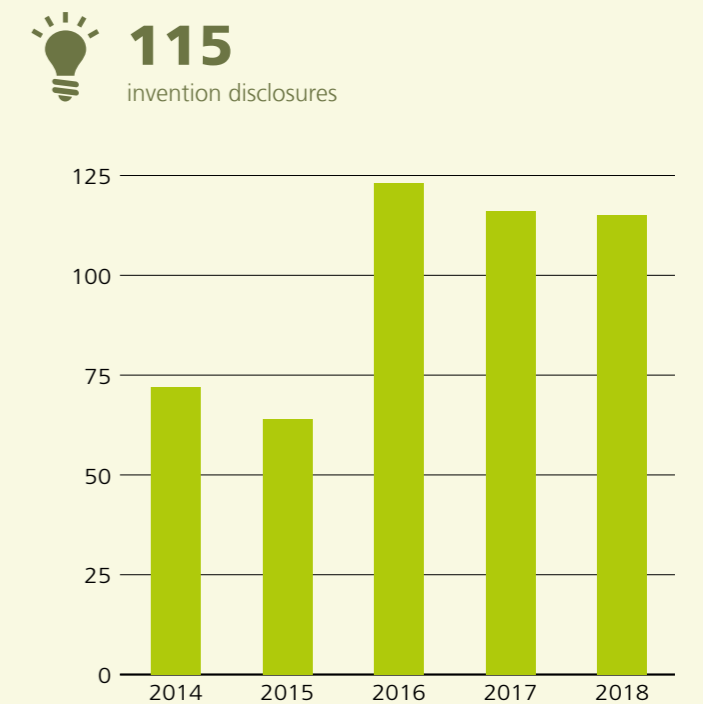
- Base funding
- Industrial revenue
- Public-service revenue
- Other revenue



New solutions for industry

We make the results of our research work available to industry in the form of patents or licenses. In 2018, employees of Fraunhofer IIS reported 115 inventions.

In first place was the Communications Systems research division, with around 50 percent of invention disclosures; next came the Audio and Media Technologies division, with around 25 percent; and then came the Positioning and Networks division, with just under 15 percent.





PROFILE OF FRAUNHOFER IIS

The Fraunhofer Institute for Integrated Circuits IIS in Erlangen is one of the world's leading application-oriented research institutions for microelectronic and IT system solutions and services. It is the largest of all Fraunhofer Institutes.

Research at Fraunhofer IIS revolves around two guiding topics:

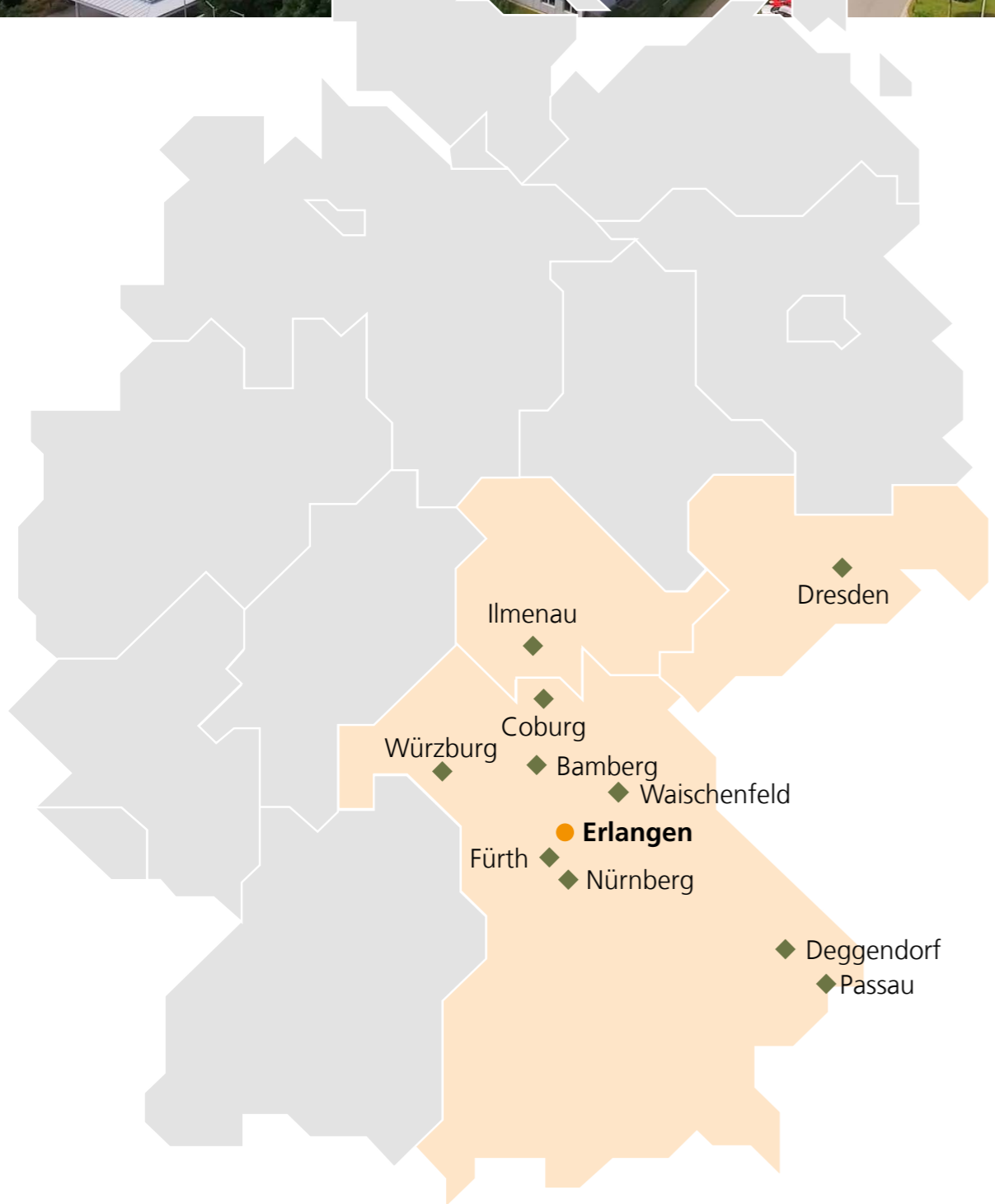
In the area of **"Audio and Media Technologies,"** the institute has been shaping the digitalization of media for more than 30 years now. Fraunhofer IIS was instrumental in the development of mp3 and AAC and played a significant role in the digitalization of the cinema. Current developments are opening up whole new sound worlds and are being used in virtual reality, automotive sound systems, mobile telephony, streaming and broadcasting. For example, every cellphone sold today contains audio technologies developed by the institute, and the sound of over half of all TV broadcasts worldwide and virtually all radio and streaming services is based on Fraunhofer codecs. On top of this, the institute's professional tools for digital film and media productions are being used around the world.

In the context of **"cognitive sensor technologies,"** the institute researches technologies for sensor technology, data transmission technology, data analysis methods and the exploitation of data as part of data-driven services and their accompanying business models. This adds a cognitive component to the function of the conventional "smart" sensor. Applications for the research results are found in connected mobility, in communication and application solutions for the Internet of Things, in the digitalization of human sensing, in product and material monitoring and in business analytics in supply chains.

Almost 1050 employees conduct contract research for industry, the service sector and public authorities. Founded in 1985, the institute has 15 locations in 11 different cities: Erlangen (headquarters), Nuremberg, Fürth, Dresden, Bamberg, Waischenfeld, Coburg, Würzburg, Ilmenau, Deggendorf and Passau. The budget of 165 million euros a year is mainly financed by contract research projects; 26 percent of the budget is made up of German federal and state funds.

 www.iis.fraunhofer.de/en

You can see the organizational structures of the individual locations in the organizational chart on the following pages.



Headquarters ●
Locations ◆

ORGANIZATION CHART



Last amended: February 2019

FRAUNHOFER-GESELLSCHAFT WORLDWIDE



The Fraunhofer-Gesellschaft co-operates with independent foreign subsidiaries in Europe, North and South America, and Singapore. In addition, Fraunhofer Representative Offices and Fraunhofer Senior Advisors worldwide form a bridge to local markets, and an office in Brussels acts as an interface between Fraunhofer and the European institutions. Numerous strategic collaborations with excellent international partners round off the Fraunhofer portfolio.



www.fraunhofer.de/
international-en



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The Advisory Board advises the institute's directors and helps to forge contacts with industry and other organizations.

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Reiner Würz, Continental Automotive GmbH, R&D Advanced Development Manager

AWARDS AND PRIZES

KlarText Prize from Klaus Tschira Foundation in "IT" category

Christof Weiß, employee at International Audio Laboratories Erlangen (AudioLabs), for the clear and intelligible presentation of ideas and results in his doctoral thesis "That's Haydn: Definitely is!" about algorithms that recognize music styles.

EAS wins with start-up collaboration at Fraunhofer Venture DemoDay

In July 2018, as part of the Fraunhofer-Gesellschaft's Tech-Bridge program, four collaborations between start-ups and Fraunhofer Institutes were able to convince the jury to fund a joint project in each case. One of the winners was the collaboration between GreenPocket and Fraunhofer IIS/EAS in a project for the preparation and editing of building energy data for use in user-friendly applications.

Joseph von Fraunhofer Prize 2018

Dr. Michael Böhnel, Nils Reims and Michael Salamon for XXL computed tomography, which permits the scanning of very large objects with X-ray technology.

Science Prize from EHI Foundation and GSI Germany in "Collaboration" category

JOSEPHS® open innovation lab for its innovative and collaborative market research approach through co-creation.

IEEE FG Test of Time Award

Bernhard Fröba (posth.) and Andreas Ernst for their 2004 paper, "Face detection with the modified census transform." According to IEEE Explorer, the paper has been cited in 172 other publications and in 81 patents; and according to Google Scholar, there have been 650 citations. As such, it served a large

portion of applied facial analysis techniques worldwide as an indispensable information source, and furthermore paved the way for the current SHORE® analysis software.

PCB Design Award from the FED Trade Association for Design and PCB and Electronics Manufacturing

Alfred Holzberger for the design of an IO board for the INCA camera system (2.5 × 2.5 × 9 cm), which was developed for extreme environmental conditions. One of the biggest challenges in designing the folding circuit board consisted in arraying the back panel components of the camera such that all external plug connections for communication with the outside world and an easily visible LED display could be housed in the system.

Fraunhofer IIS Prize 2018 for research with an outstanding practical application – Prize awarded by "Friends of Science – Friends for Fraunhofer" foundation

Dr. Frank Danzinger for the development and management of the JOSEPHS® open innovation lab.

Fraunhofer IIS Prize 2018 for research with an outstanding practical application – Prize awarded by "Friends of Science – Friends for Fraunhofer" foundation

Adrian Murtaza for his decisive contributions to the adoption of the audio codec MPEG-H Audio in several international standards.

PUBLISHING NOTES

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