Fraunhofer

IIS

FRAUNHOFER INSTITUTE FOR INTEGRATED CIRCUITS IIS

HIGHLIGHTS
2020
ANNUAL REPORT

The online version of the Annual Report is available at:

www.iis.fraunhofer.de/annualreport

Link to further information about the topic

Link to multimedia content

ONLINE

FRAUNHOFER IIS MAGAZINE

You can follow the stories featured in the Annual Report throughout the year in our online magazine. Here you will find current interviews with researchers and managers, reports on technical innovations and successes, plus films, podcasts and animations on all the latest topics from our institute.

www.iis.fraunhofer.de/magazine

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.

Cover image

"125 years since the discovery of X-rays" was a major topic at our Development Center for X-ray Technology in 2020. Our researchers impressively demonstrate what high-speed X-ray technology can achieve today. Turn to page 26 to read about how the latest technology makes it possible not only to look inside objects, but also to produce images of the dynamic processes that take place inside them.

HIGHLIGHTS

2020

ANNUAL REPORT

Dear reader,

The year 2020 brought unexpected changes and challenges for us all. Thanks to our proven resilience and flexibility, Fraunhofer IIS was well positioned to face the crisis; moreover, we contributed our expertise to research projects aimed at addressing the challenges that the coronavirus presents.

Our X-ray on Wheels mobile lab took to the streets to celebrate 125 years since the discovery of X-rays. Fully equipped with all the requisite X-ray technology, our van traveled around to perform non-destructive testing on historic exhibits. Read about more highlights in this report. In keeping with the motto #WeKnowHow, we show you what we did to address the issues of 2020, find solutions and drive forward digitalization.

This year, too, will be a challenging one. In 2021, we plan to expand our expertise in strategic fields such as artificial intelligence, quantum technologies, trusted and green electronics, 5G/6G and the IoT. This will provide the foundation for our continued success in the future.

Enjoy the read!

Prof. Albert Heuberger   Prof. Bernhard Grill   Prof. Alexander Martin

Directors of Fraunhofer IIS

CONTENTS

THE TECH EXPERTS BEHIND GERMANY'S CORONAVIRUS WARNING APP

COVID-19 has brought about some big changes. And that includes the speed at which we conducted the research that enabled us, together with T-Systems and SAP and on behalf of the Robert Koch Institute (RKI), to unveil a functional app in June 2020. We worked with our usual tenacity and perseverance, and didn't let the intense debate about data protection and availability hold back the pace of innovation: by the end of 2020, Germany's Corona-Warn-App had been downloaded over 24 million times; when it comes to data protection, the app is as secure as it gets.

Since early March 2020, our Fraunhofer expert group has been demonstrating just how quickly an idea and a promising solution can unfold in the face of a challenge. Steffen Meyer, who manages the Corona-Warn-App project at Fraunhofer IIS, and his team have been heavily involved in the provision of the app's Google/Apple exposure notification interface and in testing the technology. They have also been continuously adapting and updating the interface on the basis of expert advice and know-how gained from their research and development activities in the field of proximity detection for wireless technology, such as Bluetooth® and WLAN. The interface makes it possible to determine the length and proximity of a contact. We discussed all this in an interview with Meyer.

Mr. Meyer, how did the project come about and how quickly did you and your team have to get started with the first development steps?

Steffen Meyer: A call came through to the director of our institute from the Fraunhofer Institute for Telecommunications, Heinrich Hertz Institute, HHI – and that was our cue to begin.

AT A GLANCE

1 | 27 million downloads speak for themselves: Germany's Corona-Warn-App is one of the most successful apps there is and respects privacy and data security along German data protection guidelines.

2 | Further development of the exposure notification interface and implementation of the RKI risk model are essential for this coronavirus warning app.

3 | As experts in BLE/Wi-Fi proximity detection, we were able to provide testing to support the implementation.

1 *Our proximity detection experts perform tests for the implementation of Germany's coronavirus warning app – in realistic situations and with reference testing options.*

As Bluetooth® Low Energy specialists, we were asked to be part of the project team for a coronavirus warning app. From that point, we were all on board and we set to work. The goal was to use existing smartphone technology that everyone carries with them almost all the time. Introducing new technology wasn't an option as it would have taken too long to develop and roll out across the population.

What were the particularities of using Bluetooth® as a measurement tool?

We've been working in the field of proximity estimation using BLE-based signal strength measurement for more than ten years and have brought this technology to market in applications for manufacturing, logistics, transportation, trade shows and museums. Our experience meant we were well placed to assess the capabilities and limitations of Bluetooth®-based estimates. It was obvious that the technology could be useful here and, what's more, that it was the only tool available to the majority of the population that was suitable for fulfilling the "proximity" and "duration" detection criteria of the Robert Koch Institute's RISK score as a way to break chains of infection more quickly. One of the challenges that arose in our discussion of the app was about precision and how to make it absolutely clear to everyone that it wasn't a question of making measurements down to the nearest centimeter.

How did your team contribute to the development?

The most challenging task lays in analyzing and optimizing how the measurement data was acquired and processed behind the exposure notification interface, which was necessary for Google and Apple to launch the app on Android and iOS, respectively. At the critical stage of the project, there were repeated discussions, tests and consultations taking place at different times in the team with T-Systems and SAP, but also with Google and Apple developers. It was a mammoth task and we were working pretty much around the clock, but it was also exciting. My team at Fraunhofer IIS is made up of Wi-Fi/Bluetooth® specialists and system design and analysis experts. We worked with the necessary degree of scientific diligence but also with great commitment. We all knew how much was riding on this project.

The key part for us was the technological "translation" of the RKI risk model into the configuration parameters of the exposure notification interface for the various smartphones, plus the constant fine-tuning of the interface in order to map this model as accurately as possible. Other vital contributions from my team were the accompanying and comparative tests to implement the interface and new procedures for calibrating smartphone types.

What hurdles did you have to overcome in the app's development?

I can give you two examples. Because timing of Bluetooth® Low Energy signals isn't coordinated, the receiver needs to be "listening" all the time to make sure it captures all of the Bluetooth® Low Energy signals in its surroundings. So we proposed a method that enables longer and more frequent measurement intervals, and worked with Google and Apple to define it. This is one of the key features of the exposure notification interface that's used around the world.

When using radio signals for measurement and converting them into other readings such as distances, various influencing factors must be taken into account in the calculation and estimation. These factors include movement, other radio signals and reflective materials in the surroundings, such as metal, walls, etc. Addressing the variance of these influencing factors and weighting them against an RKI risk assessment were among the most difficult tasks.

Because Bluetooth® Low Energy can't estimate the distance of a smartphone more accurately, we have to set priorities in terms of how we deal with this inaccuracy. The German federal government decided to accept a slightly increased number of false positives and opted to test more.

What developments are next on the map?

Alongside further parallel real-life tests, we need to address increasing demand from the corporate sector. Here, too, chains of infection ought to be broken as quickly as possible. In addition, efforts are underway to integrate methods for measuring distance using acoustic signals so as to achieve even greater accuracy for certain applications.

Thanks for the interview, Mr. Meyer. ∎

CONTACT

Steffen Meyer
Positioning and Networks

Phone +49 911 58064-9450
steffen.meyer@iis.fraunhofer.de

1, 3 The first live tests were carried out with an optical reference system under coronavirus conditions at the Fraunhofer IIS L.I.N.K. Test and Application Center.

2 The tech experts behind the Corona-Warn-App, pictured here with Fraunhofer president Prof. Reimund Neugebauer, who extended the German Chancellor's thanks in person.

DIGITAL TRANSFORMATION FROM THREE PERSPECTIVES
Recently appointed head of department Dr. Nadja Hoßbach looks at digital transformation from three perspective

Dull and monotonous? Not here! Dr. Nadja Hoßbach heads up a diverse team made up of experts from the social and economic sciences, from the natural sciences and mathematics, from engineering and psychology, plus a large number of students and research assistants. Hoßbach, who holds a doctorate in information systems, took over as head of the Innovation and Transformation department at the Fraunhofer Center for Applied Research on Supply Chain Services SCS, with its 40 employees, on September 1, 2020. Together, their mission is: "To help organizations master the digital transformation," Hoßbach says.

In doing this, she and her team look at the digital transformation from three perspectives. The Future Engineering group focuses on technology: What trends and market changes are companies facing? How can machine text analysis methods be applied to process large amounts of unstructured data in order for companies to identify changes in their market and technological environment? The Business Transformation group looks at digital transformation from a corporate angle, the classic business perspective. Here, the focus is on the companies themselves: What impact does technology have on business models? What potentials do digital technologies offer for service systems and business models? And what are the organizational implications of new business models? Last but

not least, the Human Centered Innovation group addresses the human factor: How can people be involved in the development of IoT and AI systems? How must innovation labs be designed to benefit those who use and operate them?

Hoßbach's background helps her with this constant switching between perspectives. Born in Erlangen, Germany, she worked as a management consultant for nine years, which means she fully understands the corporate stance. "In that world, we had to find and work out solutions, initiate change processes and sometimes resolve conflicts of interest," Hoßbach recalls. During her subsequent doctorate at Friedrich-Alexander-Universität Erlangen-Nürnberg, her main focus was the scientific perspective. "These two angles work really well together – after all, our work at Fraunhofer IIS is all about applying findings from scientific research in the business sector," she says. In addition to being an expert in science and application, Hoßbach's experience means she is well accustomed to switching perspectives.

C O N T A C T

Dr. Nadja Hoßbach
Fraunhofer Center for Applied Research on Supply Chain Services SCS

Phone +49 911 58064-9552
nadja.hossbach@iis.fraunhofer.de

19 Africa **22** USA **165** Asia **1467** Europe

Which continents do we originate from?

61/ nationalities

1136 employees

including **88** PhD students
plus **498** assistants/interns and
18 trainees
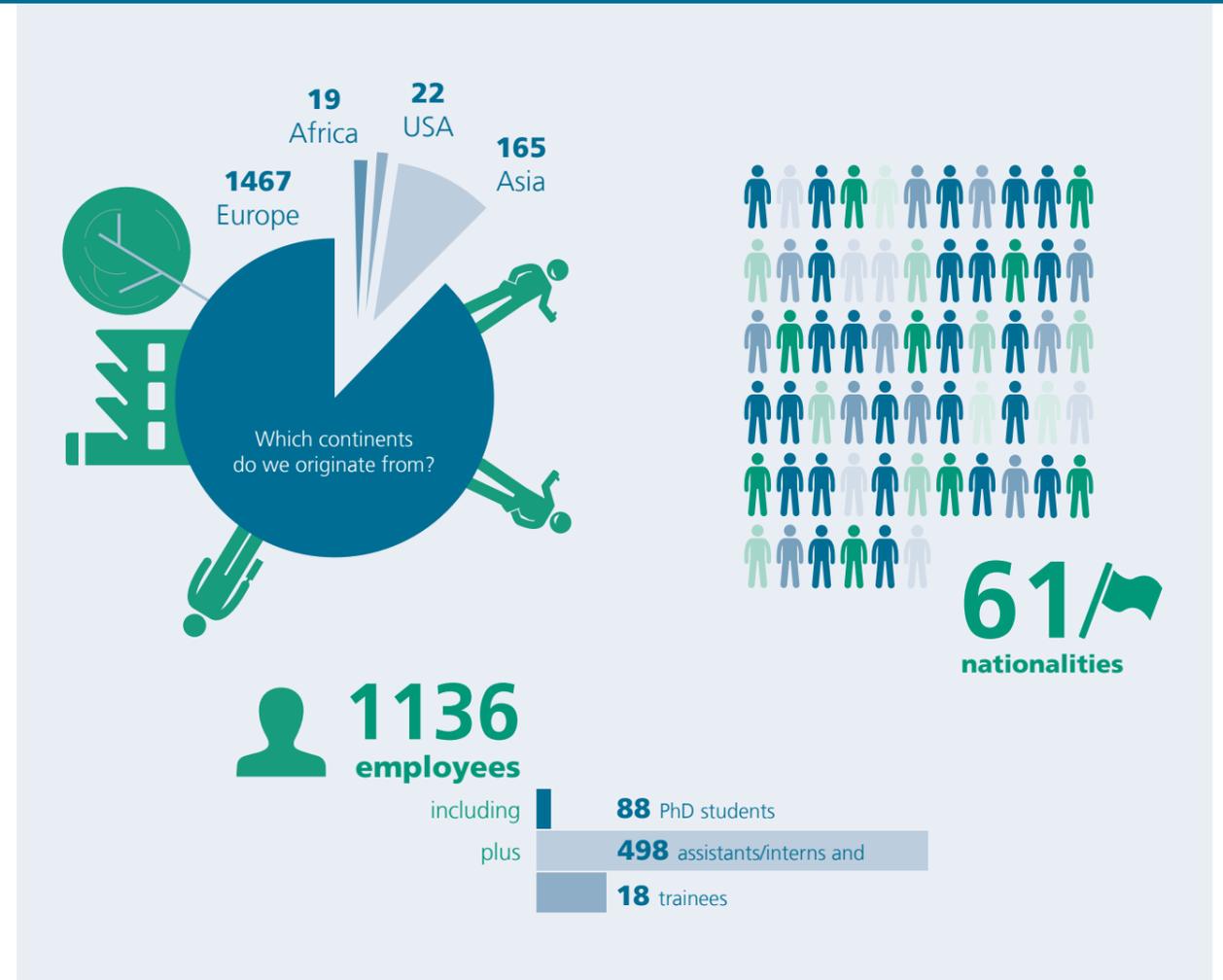
THE DIVERSITY OF THE FRAUNHOFER IIS WORKFORCE
How we use diversity as an opportunity for development

Our teams at Fraunhofer IIS are diverse and that's part of our strategy for success. The interplay of different expertise and training, but also of different cultures and unique qualities, yields perspectives and insights that would be impossible for individuals to develop on their own. In an age of increasing automation and artificial intelligence, the value of human creativity at work is growing all the time. Greater diversity in our teams empowers them to generate more creative ideas and drive the success of the institute and its partners.

AWARDS, PRIZES AND APPOINTMENTS

CELTIC-NEXT Excellence Award 2020

The European research initiative CELTIC-NEXT selected the project team led by Fraunhofer IIS as the winners of its Excellence Award 2020 in the Applications category for their ReICOvAir (Reliable Industrial Communication Over the Air) project.

2020 CNA Innovation Award

The project entitled "Energy-efficient schedule optimization of Nuremberg's subway network" won the CNA Innovation Award 2020 in the Intelligence for Transportation and Logistics category. The project consortium consisted of Fraunhofer IIS, Friedrich-Alexander-Universität Erlangen-Nürnberg and VAG Verkehrs-Aktiengesellschaft Nürnberg and was led by Dr. Andreas Bärmann from Fraunhofer IIS.

2020 DGZfP User Award

Wolfgang Holub, Chief Engineer at the Fraunhofer Development Center for X-ray Technology EZRT, received the User Award from the German Society for Non-Destructive Testing (DGZfP) for his work in the field of "Robot-based computed tomography on large components in automotive engineering."

FKTG University Graduate Award

The German TV and Film Technology Society (FKTG) recognized Eva Hasenberger, a member of the Automotive Audio Research group, for her master's thesis on binauralization in vehicle sound systems.

2020 Doctoral Dissertation Award from the University of Bamberg

Dr. Teena Chakkalayil Hassan received the award for her outstanding dissertation entitled "Towards robust and interpretable practical applications of automatic mental state analysis using a dynamic and hybrid facial action estimation approach."

Rainer Markgraf Prize 2020

For her commitment to sharing knowledge between university, research and education, Prof. Ute Schmid, Head of the Project Group for Comprehensible AI at Fraunhofer IIS, was awarded the Rainer Markgraf Prize.

Fraunhofer IIS Research Fellow

In recognition of his many years of collaboration with and support for the Fraunhofer Center for Applied Research on Supply Chain Services SCS, Prof. Freimut Bodendorf was named a Fraunhofer IIS Research Fellow. Prof. Bodendorf holds the Chair of Information Systems (Services, Processes, and Intelligence) at the Institute of Information Systems, part of the School of Business, Economics and Society at Friedrich-Alexander-Universität Erlangen-Nürnberg.

2020 Fraunhofer IIS Prize for outstanding scientific achievement

Dr. Sascha Disch was honored for his role as an irreplaceable knowledge holder and multiplier in the training of young scientists.

2020 Fraunhofer IIS Prize for research with an outstanding practical application

Michael Geyer was honored for his special achievements in expanding the strategically important licensing business model at Fraunhofer IIS.

Honorary professorship

Prof. Bernhard Grill, Institute Director at Fraunhofer IIS, received an honorary professorship at Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU).

Honorary professorship

Prof. Siegfried Fößel, a Head of Department at Fraunhofer IIS, was named honorary professor at the University of Television and Film in Munich.

Honoris causa professorship

Johann Hauer was made an honoris causa professor at Peter the Great St. Petersburg Polytechnic University.

Professorship

Prof. Frank Danzinger has been a professor for the subjects of digital business, data-driven business models and innovation spaces at Augsburg University of Applied Sciences since the winter semester 2020/21. He remains closely connected to Fraunhofer IIS in his role as coordinator of the Smart Services business unit at the Fraunhofer Center for Applied Research on Supply Chain Services SCS.

Members of Bavarian Council on AI

The following people have been appointed to the Bavarian Council on AI: Prof. Alexander Martin, Director of Fraunhofer IIS; Prof. Ute Schmid, Head of the Project Group for Comprehensible AI at Fraunhofer IIS; and Prof. Thomas Seidl, Co-leader of the Fraunhofer IIS ADA Lovelace Center at Ludwig-Maximilians-Universität München.

Joseph von Fraunhofer Prize 2020

For their robust, reliable and tamper-proof receiver technology Galileo PRS, Dr. Wolfgang Felber, Dr. Günter Rohmer and Alexander Rügamer received a Joseph von Fraunhofer Prize 2020.

Power grids, cellular networks, asset tracking: satellite navigation that provides reliable positioning and time information is needed around the globe. All satellite navigation signals that have been freely available so far, such as those transmitted by the American GPS or the Russian GLONASS, are vulnerable to interference, manipulation or in crisis situations even being cut off, whether intentionally or not. Galileo is the world's first satellite navigation system under civilian control and, with its specially protected Galileo Public Regulated Service (PRS), provides a signal that allows authorized users to navigate to positions in time and space safely and reliably – even in crisis situations.

1 *Dr. Wolfgang Felber, Dr. Günter Rohmer, and Alexander Rügamer (from left) received the Joseph von Fraunhofer Prize for their robust, trustworthy and tamper-proof receiver technology.*

FRAUNHOFER IIS –
YOUR PARTNER

HUNTING FOR CLUES WITH "FRAUNHOFER X-RAY ON WHEELS"

A mobile computed tomography system is helping to digitalize European heritage sites

It has been 125 years since Wilhelm Conrad Röntgen almost by chance discovered the X-rays, which many languages still refer to as Röntgen radiation. His discovery was the beginning of a revolution in diagnostics, and not just in medicine. Other sciences, too, including archeology, are reaping the benefits as research and development continues for this technology.

A tiny yet fully equipped X-ray lab

The brainchild of the Fraunhofer Development Center for X-ray Technology EZRT, the X-ray on Wheels celebrates the 125th anniversary of the discovery of X-rays in its own very special way. Inside the vehicle is a fully equipped mobile lab featuring latest-generation technology. Its CTportable160.90 X-ray system is capable of scanning objects that are relatively easy to irradiate with a height of up to 200 millimeters and a diameter of up to 70 millimeters in three dimensions at a resolution in the micrometer range. It provides an energy spectrum of up to 90 kiloelectronvolts for recording the X-ray projections.

"Developed in-house at the institute, the CTportable product family is ideal for mobile use. We can use our X-ray on Wheels to present the versatility of X-ray technology at different locations," explains Dr. Norman Uhlmann, division director of the Fraunhofer Development Center for X-ray Technology EZRT in Fürth.

Key enabler of digitalization for items of cultural heritage

Fragile and valuable museum exhibits in particular benefit from this gentle method of non-destructive material testing. Rather than exposing historically unique and irreplaceable artifacts to any risk during transportation, the Fraunhofer CT system drives to the exhibit instead.

To mark the anniversary of the X-rays' discovery, the mobile lab helped to investigate a whole host of interesting exhibits in 2020. In addition to fragments of Otto Lilienthal's original glider, the X-ray on Wheels revealed the inner workings of the highly complex fabric used to make an astronaut's glove.

It is also playing a key role in digitalizing European heritage sites. Our advanced CT systems help tackle this tremendous challenge and by capturing the objects in digital form, provide unprecedented insights into otherwise inaccessible knowledge.

🔗 www.iis.fraunhofer.de/ctportable-en

1 To mark the anniversary of the discovery of X-rays 125 years ago, the Fraunhofer X-ray on Wheels mobile lab toured Germany.

2 Minister of State Hubert Aiwanger (left) opened the 5G Bavaria Test Center and Industry 4.0 Test Bed in the presence of Prof. Albert Heuberger, executive director of Fraunhofer IIS.

NEW TEST CENTER INAUGURATED FOR 5G-BASED SOLUTIONS

With our foresight and drive, we play a key role in keeping innovation going – even in times of crisis – and we work hard to advance it. In 2020, for example, we opened the 5G Bavaria Test Center and Industry 4.0 Test Bed.

With its 5G Bavaria initiative, the State of Bavaria supports companies by providing a unique offer of a test center and two testbeds for Industry 4.0 and automotive applications at Fraunhofer IIS in Erlangen and Nuremberg.

The development of 5G-based solutions will be a key step in the implementation of new IoT applications. By using the 5G Bavaria test environment, companies can close the gap between the rapidly advancing standardization of 5G and its practical implementation for industrial use. They can use the facilities to test applications under realistic conditions and benefit from the neutral expertise Fraunhofer IIS offers as a partner for research, technology development and evaluation, and technical consulting.

WE CONNECT ONLINE – TRAINING IN CORONAVIRUS TIMES

Adaptive Systeme
"Webinar Wednesdays" covering topics such as:
– Design Methodology: Functional safety in accordance with ISO 26262; System Modeling with SystemC
– Efficient Electronics: Automation for accelerated analog IP migration; Hardware for AI
– Intelligent Sensors and Actuators: Sensors for complex industrial image processing
– Distributed Data Processing and Control: Renewable energy transition goes digital; Energy management in production in accordance with DIN EN ISO 50001; Fail-safe wireless systems in industry; Predictive maintenance & data-based quality monitoring

Audio and Media Technologies
– MPEG-H Audio online seminar series: Overview, latest developments, live demonstrations, Q&A
– "Comprehensive solutions and expertise for the entire broadcast chain" – webinar hosted by our team of experts for digital radio technologies
– "Next Generation Audio and Video technologies and the future of broadcast and streaming": with partner companies, we explain the steps to next-generation television and streaming

– Video tutorials on how to use MPEG-H Audio production tools in live environments or in the studio

Smart Sensing and Electronics
– AI: Hands-on "Deep Learning and Computer Vision" workshop
– Digital Health: Unlocking the potential of medical-grade wearables using CardioTEXTIL as an example; Digital health applications and digital patient management; Medical communication protocols for POC devices
– ASICs: From idea to product, HallinMotion® – The technology for multidimensional position measurement, Condition monitoring with integrated sensor systems

Supply Chain Services
– Digital transformation in industry and business – Knowledge snacks: New e-learning series with all relevant methods and processes for successful implementation in practice, from innovative technologies to extraordinary business models

🔗 www.iis.fraunhofer.de/education

FRAUNHOFER IIS IN FIGURES

A growing workforce

Our employees are the cornerstone of the institute's success. In 2020, our workforce again experienced record growth. Compared to 2019, the number of staff on the books rose from 1112 to 1136, 88 of whom are PhD students. In addition, we employed 498 student assistants and 18 trainees at the institute.

- Employees
- Student assistants
- Trainees

1136
employees
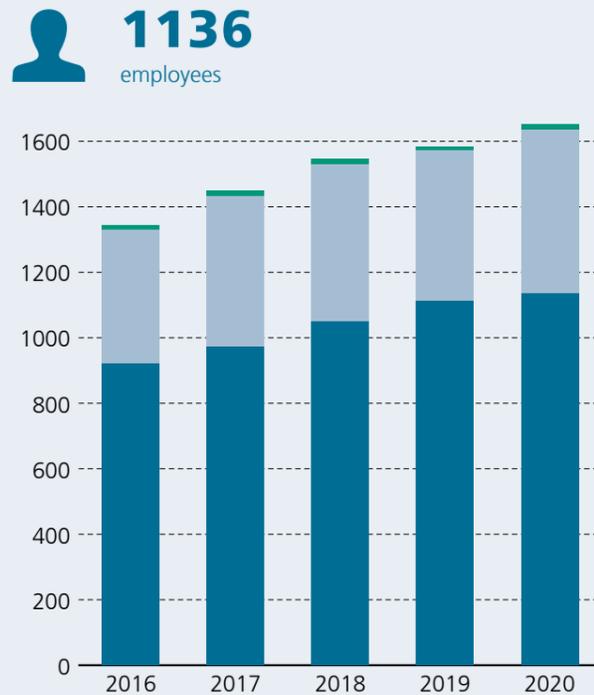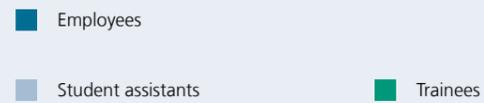
41 percent industrial earnings

Using carryovers from previous years, Fraunhofer IIS had a balanced budget in 2020. Fully 41 percent of its funds came from industry and business. The base funding, provided by the German federal and state governments, amounted to 29 percent. Meanwhile, 24 percent of the budget came from public-service revenue. Additional revenue derived from foundations and other research institutions.

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

167.9m €
funding
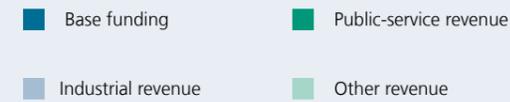
Another year of many invention disclosures

In 2020, as in previous years, most of the invention discloses we submitted originated from our Communications Systems and Audio and Media Technologies research areas for subject matter such as 5G and radio communications, as well as speech and audio coding.

In addition, Fraunhofer IIS's established structures engaged in intellectual property activities with other institutes within the Cognitive Internet Technologies cluster, which account for a significant share of the invention disclosures.

95
invention disclosures

ORGANIZATIONAL CHART

Management of the Institute
Prof. Dr. Albert Heuberger (executive)
Prof. Dr. Bernhard Grill
Prof. Dr. Alexander Martin

Deputy Directors
Prof. Dr. Randolf Hanke
Dr. Peter Dittrich

Research Management
Dr. Peter Dittrich
IT Services Florian Freund
Staff Matthias Rose

Senior Director Administration, Finance and Human Resources
Dr. Peter Dittrich

Audio and Media Technologies
Prof. Dr. Bernhard Grill — ER

Development Center X-ray Technology EZRT
Dr. Norman Uhlmann — FÜ

Smart Sensing and Electronics
Dr. Jens-Uwe Garbas
Dr. Denise Müller-Friedrich — ER

Communication Systems
Michael Schlicht — ER

Positioning and Networks
Dr. Günter Rohmer — N

Fraunhofer Center for Applied Research on Supply Chain Services SCS | Prof. Dr. Alexander Pflaum, Dr. Roland Fischer — N

Engineering of Adaptive Systems EAS
Dr. Peter Schneider — DD

Audio
Johannes Hilpert

Media Systems and Applications
Harald Fuchs

Application-specific Methods and Systems | Alexander Ennen, Dr. Stefan Gerth

Sensory Perception & Analytics
Stephan Gick

Broadband and Broadcast
Bernhard Niemann

Distributed Systems and Security
Karlheinz Ronge

Analytics
Christian Menden

Design Methodology
Dr. Roland Jancke

Audio for Communications
Manfred Lutzky

Moving Picture Technologies
Prof. Dr. Siegfried Fößel

Contactless Test and Measuring Systems
Dr. Peter Schmitt

Image Processing and Medical Engineering
Dr. Christian Münzenmayer

Electronic Measurements and Signal Processing
Prof. Dr. Giovanni Del Galdo

Precise Positioning and Analytics | Thomas von der Grün, Dr. Christopher Mutschler

Data Spaces and IoT Solutions
Prof. Dr. Andreas Harth

Distributed Data Processing & Control
Dr. Dirk Mayer

Audio for Embedded Systems
Dr. Nikolaus Färber

Patents and Licensing
Stefan Geyersberger

CT in Metrology
Dr. Steven Oeckl (acting) — DEG

Integrated Circuits and Systems
Dr. Norbert Weber

Radio Communication Systems
Dr. Gerd Kilian

Satellite Based Positioning Systems
Dr. Wolfgang Felber

Innovation and Transformation
Dr. Nadja Hoßbach

Efficient Electronics
Andy Heinig

AudioLabs-IIS
Dr. Frederik Nagel

Semantic Audio Processing
Oliver Hellmuth

Magnetic Resonance and X-ray Imaging
Dr. Karl-Heinz Hiller — WÜ

Integrated Sensor Systems
Harald Neubauer

RF and SatCom Systems
Rainer Wansch — IL

Self-Powered Radio Systems
Josef Bernhard

Intelligent Sensors and Actuators
Dr. Dirk Mayer (acting)

Business
Marc Gayer

Staff Audio and Media Technologies
Matthias Rose

Production Monitoring
Dr. Steven Oeckl

humAIn-IIS
Dr. Frederik Nagel

ER | Headquarters Erlangen
Am Wolfsmantel 33
91058 Erlangen
Phone +49 9131 776-0

N | Location Nürnberg
Nordostpark 84 (SCS: 93)
90411 Nürnberg
Phone +49 911 58061-9500

FÜ | Location Fürth
Flugplatzstraße 75
90768 Fürth
Phone +49 911 58061-7500

DD | Institutsteil Entwicklung Adaptiver Systeme EAS
Zeunerstraße 38
01069 Dresden
Phone +49 351 4640-701

DEG | Application Center for CT in Metrology
Dieter-Görlitz-Platz 2
94469 Deggendorf
Phone +49 991 3615678

WÜ | Magnetic Resonance and X-ray Imaging Department
Am Hubland
97074 Würzburg
Phone +49 931 31830-60

IL | Electronic Measurements and Signal Processing
Am Vogelherd 90
98693 Ilmenau
Phone +49 3677 69-4280

Last updated: March 2021

MEMBERS OF THE ADVISORY BOARD

RESEARCH FAB MICROELECTRONICS GERMANY

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

Dr. Dietmar Schill, Sony Europe Ltd.
(Chairman of the Advisory Board)

Dr. Annerose Beck, Saxon State Ministry for Science, Culture and Tourism

Dr. Bernd Ebersold, Thuringian Ministry for Economic Affairs, Science and Digital Society

Dr. Astrid Elbe, Intel Deutschland GmbH

Jörg Fürbacher, EURO-LOG AG

Klaus Helmrich, Siemens AG

Prof. Dr. Joachim Hornegger, Friedrich-Alexander-Universität Erlangen-Nürnberg

Anton Kathrein

Prof. Franz Kraus, ARRI AG

Dr.-Ing. Walther Pelzer, German Aerospace Center (DLR)

Dr. Heike Prasse, German Federal Ministry of Education and Research

Prof. Dr. Godehard Ruppert, Former President of the University of Bamberg

Dr. Alexander Tettenborn, German Federal Ministry for Economic Affairs and Energy

Dr. Isabel Thielen, THIELEN Business Coaching GmbH

Norbert Michael Weber, German Federal Ministry of Defence

Jürgen Weyer, NXP Semiconductors

MinDirig Dr. Manfred Wolter, Bavarian Ministry of Economic Affairs, Regional Development and Energy

One-stop shop: From basic research to customer-specific product development

Since April 2017, Fraunhofer IIS and 12 other member institutes have been part of the cross-site collaboration Research Fab Microelectronics Germany (FMD). With over 2000 scientists from the Fraunhofer Group for Microelectronics and the Leibniz institutes FBH and IHP, this research association is the largest of its kind and leads the world in R&D on applications and systems in micro- and nanoelectronics.

Consolidating the FMD

The FMD's goal is to conduct research and development in Germany across several locations. Its inauguration phase, which concluded in 2020, was supported by the German Federal Ministry of Education and Research (BMBF) with around 350 million euros. This mainly involved modernizing the research equipment of the 13 participating institutes of the Fraunhofer-Gesellschaft and the Leibniz Association. A key element of the FMD's strategic development in 2020 was drawing up and agreeing on a concept for sustainable operation once the initial project phase was complete.

Versatile cooperation opportunities

In addition to the range of services for its customers from industry, FMD also offers a wide variety of cooperation opportunities for its partners in science. Among the highlights are services that aim directly at processing research questions cooperatively, for example through collaborative work in joint projects and the operation of what are known as Joint Labs. In addition, it is possible to commission FMD institutes to test basic research concepts in the institutes' facilities with regard to their suitability in more application-oriented environments. Good examples of cooperation between FMD and universities as well as other institutions of higher education include the ASCENT+ project, the "iCampµs" research collaboration and the SmartBeam-Lab Joint Lab in Duisburg.

www.forschungsfabrik-mikroelektronik.de/en

Last updated: January 2021

FRAUNHOFER-GESELLSCHAFT WORLDWIDE
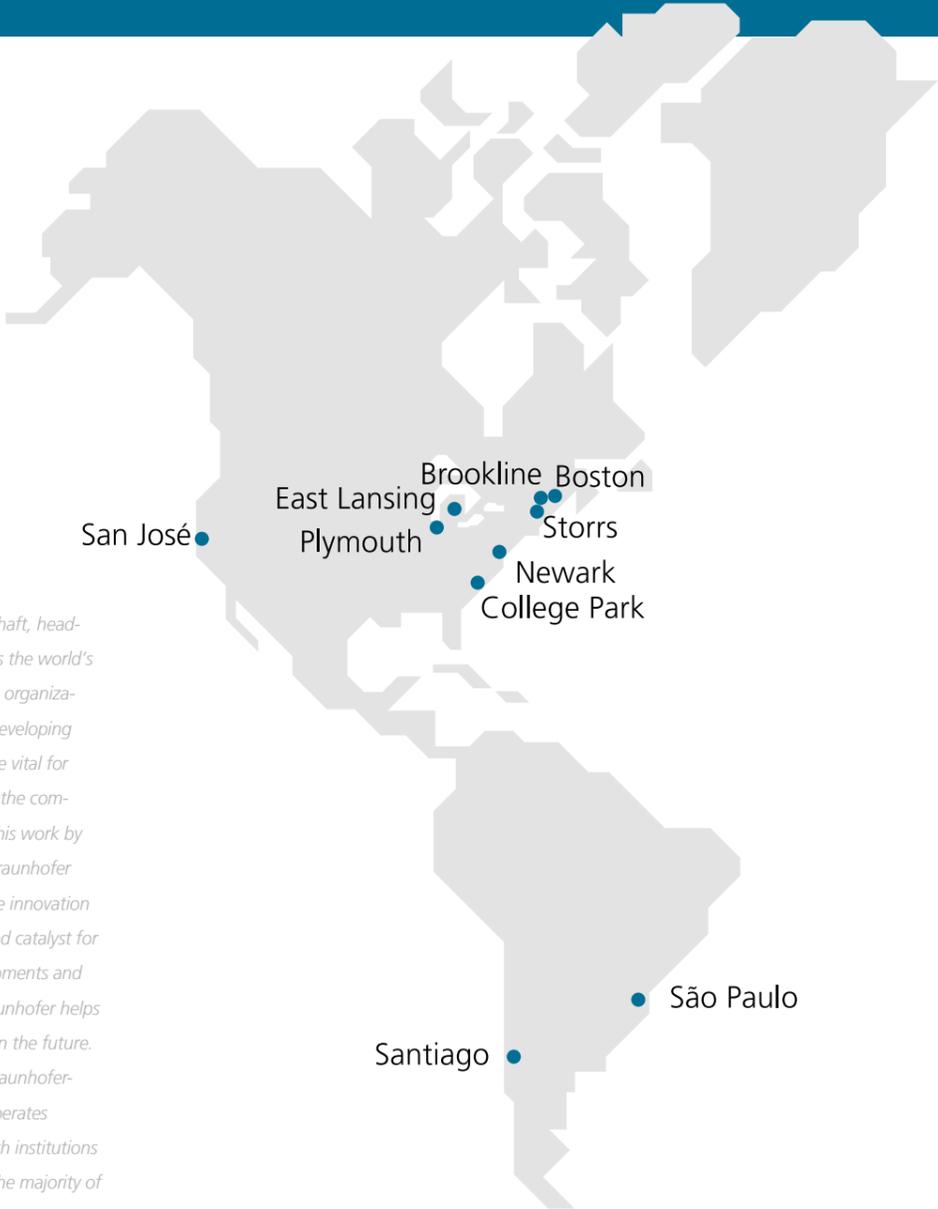
The Fraunhofer-Gesellschaft, head-quartered in Germany, is the world's leading applied research organization. With its focus on developing key technologies that are vital for the future and enabling the commercial exploitation of this work by business and industry, Fraunhofer plays a central role in the innovation process. As a pioneer and catalyst for groundbreaking developments and scientific excellence, Fraunhofer helps shape society now and in the future. Founded in 1949, the Fraunhofer-Gesellschaft currently operates 75 institutes and research institutions throughout Germany. The majority of the organization's 29,000 employees are qualified scientists and engineers, who work with an annual research budget of 2.8 billion euros. Of this sum, 2.4 billion euros are generated through contract research.

San José
East Lansing
Plymouth
Brookline Boston
Storrs
Newark
College Park
São Paulo
Santiago

Gothenburg
Glasgow
Dublin
Brussels
Munich
Vienna
Bolzano
Budapest
Porto
Graz
Ercolano
Moscow
Cairo
Lavon
Bangalore
Ampang
Singapore
Jakarta
Beijing
Seoul
Tokyo
Pretoria
Stellenbosch

www.fraunhofer.de/international

Last updated: January 2021

The Fraunhofer-Gesellschaft is the world's leading applied research organization. With its focus on developing key technologies that are vital for the future and enabling the commercial exploitation of this work by business and industry, Fraunhofer plays a central role in the innovation process. Based in Germany, Fraunhofer is an innovator and catalyst for groundbreaking developments and a model of scientific excellence. By generating inspirational ideas and spearheading sustainable scientific and technological solutions, Fraunhofer provides science and industry with a vital base and helps shape society now and in the future.

At the Fraunhofer-Gesellschaft, interdisciplinary research teams work together with partners from industry and government in order to transform novel ideas into innovative technologies, to coordinate and realize key research projects with a systematic relevance, and to strengthen the German and the European economy with a commitment to creating value that is based on human values. International collaboration with outstanding research partners and companies from around the world brings Fraunhofer into direct contact with the key regions that drive scientific progress and economic development.

Founded in 1949, the Fraunhofer-Gesellschaft currently operates 75 institutes and research institutions. The majority of our 29,000 staff are qualified scientists and engineers who work with an annual research budget of 2.8 billion euros. Of this sum, 2.4 billion euros are generated through contract research. Around two thirds of Fraunhofer's contract research revenue is derived from contracts with industry and publicly funded research projects. The remaining third comes from the German federal and state governments in the form of base funding. This enables the institutes to work on solutions to problems that are likely to become crucial for industry and society within the not-too-distant future.

Applied research also has a knock-on effect that is felt way beyond the direct benefits experienced by the customer: Our institutes boost industry's performance and efficiency, promote the acceptance of new technologies within society and help train the future generation of scientists and engineers that the economy so urgently requires.
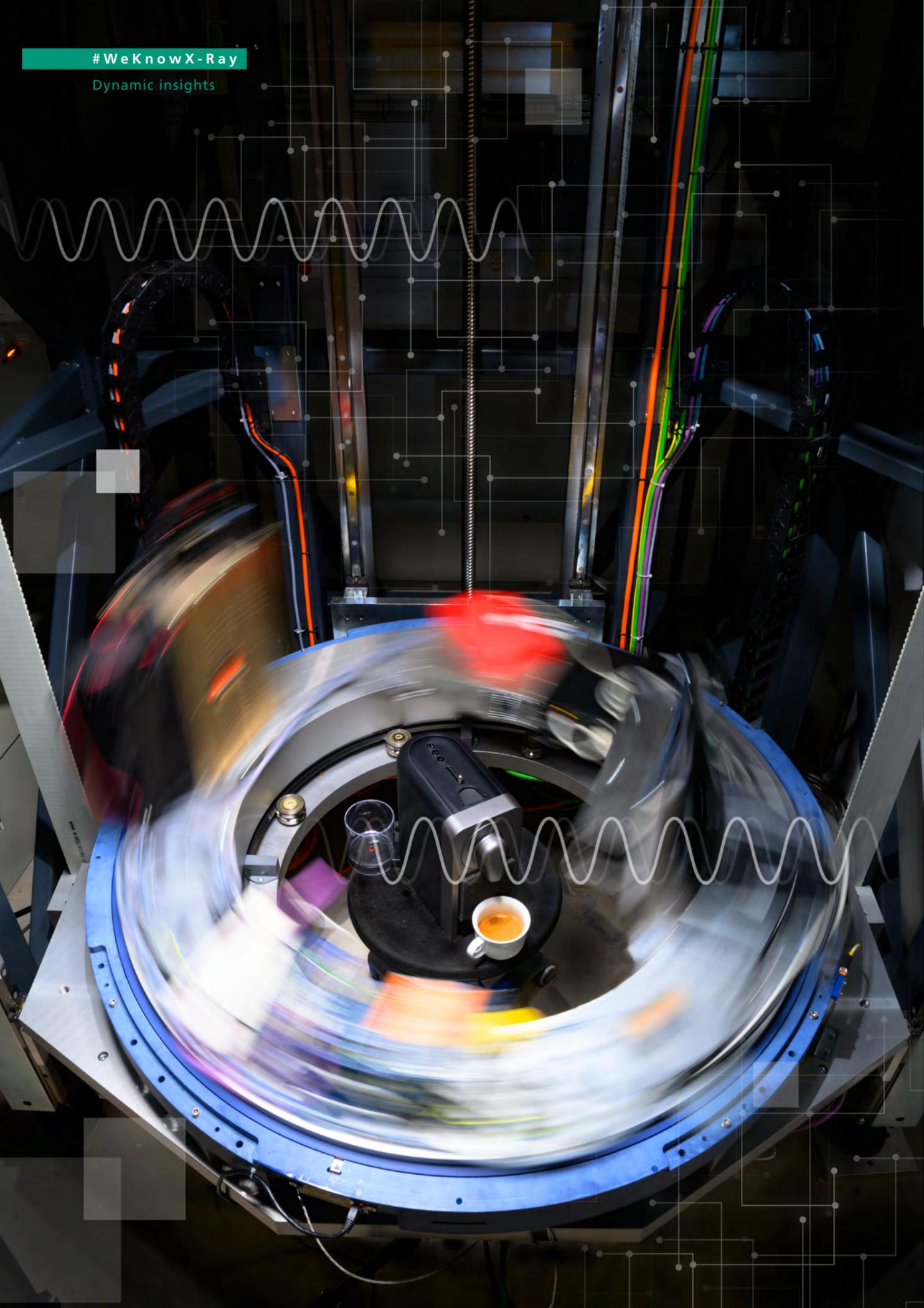
Our highly motivated staff, working at the cutting edge of research, are the key factor in our success as a scientific organization. Fraunhofer offers researchers the opportunity for independent, creative and, at the same time, targeted work. We therefore provide our employees with the chance to develop the professional and personal skills that will enable them to take up positions of responsibility at Fraunhofer, at universities, in industry and within society. Students who work on projects at Fraunhofer Institutes have excellent career prospects in industry by virtue of the practical training they enjoy and the early experience they acquire of dealing with contract partners.

The Fraunhofer-Gesellschaft is a recognized non-profit organization that takes its name from Joseph von Fraunhofer (1787–1826), the illustrious Munich researcher, inventor and entrepreneur.

main locations ●
other locations ○

Itzehoe
Rostock
Lübeck
Stade
Bremerhaven
Hamburg
Oldenburg
Bremen
Berlin
Wolfsburg
Hannover
Braunschweig
Magdeburg
Potsdam
Teltow
Wildau
Lemgo
Goslar
Cottbus
Münster
Paderborn
Halle
Schwarz-heide
Gelsenkirchen
Hamm
Soest
Göttingen
Oberhausen
Dortmund
Schkopau
Leipzig
Bochum
Kassel
Duisburg
Schmallenberg
Leuna
Dresden
Zittau
Willich
Sankt Augustin
Jena
Freiberg
Aachen
Bonn
Gießen
Erfurt
Hermsdorf
Euskirchen
Chemnitz
Wachtberg
Remagen
Frankfurt
Hanau
Ilmenau
Zwickau
Mainz
Alzenau
Coburg
Münchberg
Aschaffenburg
Bamberg
Bayreuth
Darmstadt
Würzburg
Waischenfeld
Kaiserslautern
Erlangen
Wertheim
Sulzbach
Fürth
St. Ingbert
Mannheim
Nürnberg
Sulzbach-Rosenberg
Saarbrücken
Karlsruhe
Pfinztal
Regensburg
Straubing
Ettlingen
Esslingen
Stuttgart
Deggendorf
Passau
Augsburg
Freising
Freiburg
Garching
München
Weßling
Rosenheim
Kandern
Holzkirchen
Prien
Efringen-Kirchen

The Fraunhofer-Gesellschaft currently operates 75 institutes and research institutions in Germany.

DYNAMIC INSIGHTS

Optical slow-motion recordings provide insights into dynamic processes. But they show only processes that are actually visible; what happens inside objects during such processes remains unclear. This is where high-speed X-ray detectors come into play. The Fraunhofer Development Center for X-ray Technology EZRT is opening up completely new possibilities for analyzing dynamic processes by means of a synchronous and same-perspective combination of optical high-speed imaging and X-ray imaging.

With a loud bang, a car hits a bollard wrapped in bright warning colors. The plastic of the bumper splinters and the car body deforms, almost elegantly wrapping itself around the obstacle. In behaving as they did, the materials responded precisely as the vehicle designers intended. A meticulously prepared crash test like this is designed to demonstrate the correct engineering and safety of the vehicle – a way to show that all the previous calculations and simulations were on the mark.

To this end, the deformation of the vehicle is recorded exactly as it happened using high-speed optical cameras. Examining one image at a time, the experts can piece together how the test matches up with the calculations. Their aim is to make sure that the material on the outside of the vehicle deforms precisely as planned in order to provide maximum protection for hypothetical occupants.

AT A GLANCE

1 | More than 1000 X-ray images per second give detailed insights into hidden dynamic processes.

2 | Optical slow-motion images and X-ray images are recorded synchronously to provide a direct comparison.

3 | 4DCT enables time-resolved three-dimensional imaging of non-periodic processes.

1
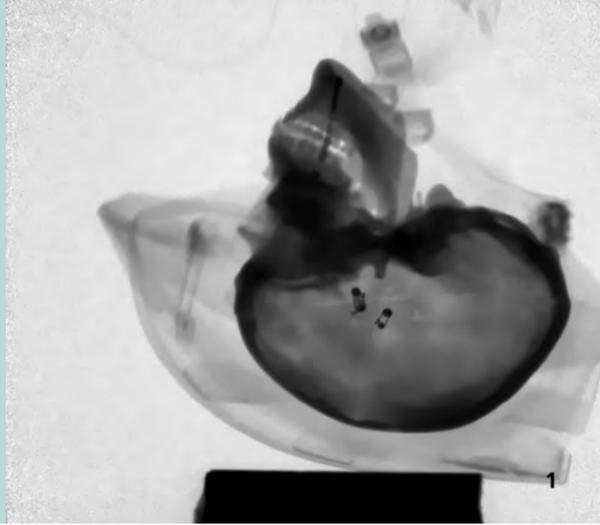
"THE FINDINGS ARE PROMISING AND PROVIDE VALUABLE INSIGHTS – ESPECIALLY FOR THE ADVANCE DEVELOPMENT OF NEW PRODUCTS."

Dr. Norman Uhlmann, division director of Fraunhofer EZRT

But what, exactly, happens inside the vehicle at the moment of impact? How do the load-bearing structures change? Are the forces transmitted and distributed to the various components as intended? Engineers are desperate to get the answers to such questions. In collaboration with researchers from the Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut, EMI, the Fraunhofer-internal research project MAVO fastXcrash aims to develop basic principles that will provide answers to questions like these.

XEye: A look inside at over 1000 frames per second

A key component is the X-ray detector, which, in conjunction with the X-ray source, is responsible for the quality of the X-ray images produced. Researchers at the Fraunhofer Development Center for X-ray Technology EZRT have developed a technology that, depending on the energy of the X-ray source, can be used to produce high-speed X-ray images of almost any size. And it can do this at high resolution, at up to 6000 frames per second and with pixel sizes starting at 200 μm. If such high speeds are not required, more detailed images can also be provided starting at a pixel size of 45 μm. The key is the patented XEye technology developed at the Fraunhofer EZRT, which enables X-ray detectors with, for example, an active area of 1.2 m × 0.8 m and a pixel size of 400 μm. The sensitivity of these detectors has been increased to such an extent that even with standard industrial X-ray sources at 1000 frames per second, the image quality they achieve is sufficient to analyze internal processes, depending on the object to be X-rayed. Previously, modeling clay was laboriously added as an indicator to analyze the extent to which a component deforms or moves; now, a digital high speed recording tracks the process more quickly, reliably and in greater detail.

By additionally using the VEye detector in front of the X-ray tube, high-speed optical images can be created from the perspective of the XEye X-ray detector. This enhances understanding of the internal structures.

Added value for product development

One of the first practical applications of this technology came in collaboration with the Fürth-based sporting goods manufacturer UVEX Sports. In crash tests with an artificial skull, the material of a bicycle helmet had to demonstrate that it behaved as the designers expected to provide the wearer with the best possible protection in an emergency.

Numerous sectors set to benefit

In addition to failure and deformation analyses, the method is also suitable for observing flow or mixing processes. What is the ideal distribution of hot water in an espresso machine's portafilter to create the best-tasting coffee? To answer questions such as these, the technology can be combined with computed tomography to record a change in volume over a period of time. This method, also known as 4DCT, allows volume changes to be recorded on a second-by-second basis, which makes it possible to visualize the water flow through the ground coffee in 3D. Construction of a 4DCT demonstrator to answer these and other exciting questions is currently underway in the EZRT's laboratories, and perhaps at some point in the future it will be possible to record a car crash test in 4D as well. ∎

▶ youtu.be/caDkEOuDRuA
youtu.be/CyyWRcGbsEA

1 *Crash test using an artificial skull. X-ray technology makes it possible to track the progression of the impact in slow motion.*

CONTACT

Thomas Kestler
Fraunhofer Development Center for X-ray Technology EZRT

Phone +49 911 58061-7611
thomas.kestler@iis.fraunhofer.de

1

2

3

RESTORATION OF A STRADIVARI CELLO PUT TO THE TEST

3D CT is used to determine if the restoration of a historic Stradivari cello was successful

Restoration work on musical instruments is always a balancing act: the art is to preserve the original sound as faithfully as possible while restoring or even replacing the majority of the sound-producing components. In the case of the "Barjansky" cello, extra special care was needed because the instrument was crafted by legendary master luthier Antonio Stradivari. The instrument is named after the Russian virtuoso Alexandre Barjansky.

Its restoration involved replacing the inner lining, which was over 300 years old, with a new lining produced by a CNC milling machine. To evaluate the results of the restoration work, the owners of the culturally and historically significant musical instrument called on the X-ray experts at the Fraunhofer Development Center for X-ray Technology EZRT as part of the MUSICES research project.

For this project, funded by the German Research Foundation, the Germanisches Nationalmuseum (GNM) in Nuremberg joined forces with the EZRT to develop guidelines and procedural instructions for the three-dimensional computed tomography (3D CT) of musical instruments. State-of-the-art 3D CT was used to precisely measure the body of the valuable cello to ensure that the restored lining was an exact fit.

The customer, ALAGO Art & Strings GmbH, is very satisfied with the results. "We were so pleased that high-resolution CT scans made it possible for us to confirm that the new lining fits accurately," says publisher and Stradivari expert Jost Thöne.

He will be publishing a study of the computed tomography examination of the Barjansky cello in early 2021 as part of his monograph and unique documentation of this extraordinary instrument. And the practical test after the restoration work revealed that the cello delivered a brilliant performance with exceptional sound.
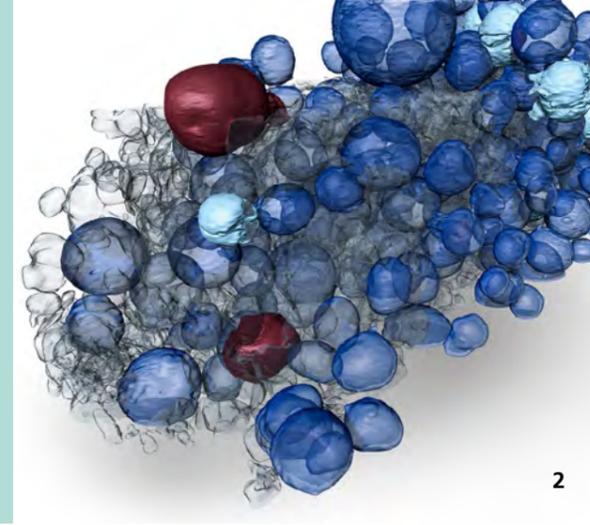
NanoCT SYSTEM NOW COMMERCIALLY AVAILABLE

Enhanced NanoCT system enables users to perform even faster scans

The constant miniaturization of electronics and mechanics opens up completely new design possibilities and processes, but it also comes with a problem: materials and component parts are now often too fine and complex to be examined using conventional methods.

To enable industry to handle these special requirements, researchers at the Fraunhofer Development Center for X-ray Technology EZRT have developed a system based on nano-computed tomography. The "ntCT" system can achieve measuring times of just a few hours for a complete CT scan with a general resolution of 200 nm and a resolution of detail of 50 nm.

As the result of a cooperation with the system integrator ProCon X-Ray, this system for non-destructive material testing is now commercially available.

ntCT works using the latest generation of X-ray tubes. Compared with the first generation of the system from 2018, the new ntCT substantially reduces measuring times while offering the same outstanding resolution. Such features are of particular interest to industrial customers looking to integrate the system into their production environment for testing purposes.
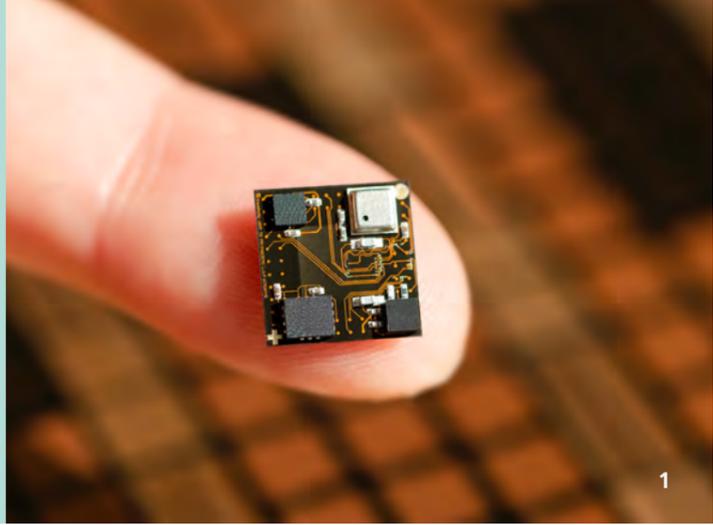
"Thanks to the control software developed specifically for the system, we can provide industrial customers with a complete analytic environment," says Dr. Christian Fella, Manager of the NanoCT Systems group.

🔗 www.iis.fraunhofer.de/ntct

2 3D analysis with microscopic resolution: One application, as shown here, is to perform quality control and failure analysis on lithium electrodes for battery research with a voxel sampling of 140 nanometers.

3 Compact standalone design for easy integration into the lab environment. Measuring 2.2 m × 1.2 m, the ntCT system is a unique solution for high-resolution measurements; its technology is far superior to that of established industrial micro-CT scanners.

1 The valuable instrument was mounted on the turntable of the 3D computed tomography scanner in such a way that it did not vibrate when rotating.

1

2

CONFIGURABLE SENSOR PLATFORM IN MODULAR FORMAT

USeP enables SMEs to offer their customers customizable IoT and edge computing solutions

The rapid pace of technological development in the field of microelectronics poses considerable challenges for small and medium-system providers in particular. The time and costs involved in the development and manufacturing of electronics for the Internet of Things (IoT) or edge computing continue to increase. Especially powerful, energy-saving and highly integrated solutions are needed that cannot be achieved with standard semiconductors. To be able to offer customers such solutions calls for an approach that is profitable even for small system providers.

To this end, the USeP – universal sensor platform – project team has joined forces with three Fraunhofer Institutes in Saxony and Globalfoundries Dresden to work on a flexibly configurable 3D sensor platform in modular format. They are being supported by colleagues in Berlin, Erlangen and Garching.

This novel sensor platform consists of a central control unit and a powerful computing cluster with nine 32-bit RISC-V processors that can be individually configured for the respective application. It also has a large number of analog and digital interfaces for numerous sensors and actuators. Globalfoundries' 22FDX® 22 nm fully depleted SOI has been selected as the platform's semiconductor technology. The project partners bring their expertise in innovative

packaging to the table, plus know-how in concept development, system design, processors, sensor technology and data transmission as well as simulation and testing. Flexible housing technology along with the adapted design environment allow for individual application scenarios, enabling the integrated 3D system to be produced cost-effectively and flexibly adapted to application-specific requirements.

The USeP project is supported by the Free State of Saxony and the European Union as part of the European Regional Development Fund (ERDF). Responsibility for managing the project lies with the IIS's Engineering of Adaptive Systems division EAS in Dresden.

🔗 www.eas.iis.fraunhofer.de/usep-en

SEMULIN – INTERACTION FOR AUTOMATED DRIVING

Our human-machine interface puts people center stage

In the SEMULIN project, which is funded by the German Federal Ministry for Economic Affairs and Energy (BMWi), we are developing a self-supporting, natural human-machine interface (HMI) for automated driving. The final demonstrator will offer options for interaction based on human senses and thus enhance the user experience and increase acceptance.

Increasing complexity and stringent requirements mean that user interfaces are playing a major role in automated driving because they must support several functions, process a great deal of information and offer a high degree of usability. But there are still limits to the natural interaction between occupants and vehicles, especially when it comes to switching between or combining the various modes and functions (facial expressions, speech, lighting, etc.). This is precisely where the SEMULIN project comes in. To develop a human-focused HMI with tailored system architecture, we are investigating all available modes with a view to intelligently interpreting and consolidating the aggregated sensor data. This involves harnessing established technologies, including SHORE® – our face detection and analysis software designed for video-based emotion recognition.

Machine learning and artificial intelligence methods and their multimodal applications help make assertions about the driver's condition, identify their intentions and derive their potential reactions. The aim of new approaches such as interactive learning is to allow the system to continuously adapt itself to the user's needs, both to enhance interaction and increase user acceptance. Our development process incorporates ethical, legal and social implications (ELSI) as well as psychological models.

The SEMULIN project was launched on November 1, 2020 and is scheduled to run until October 31, 2023. The project consortium is made up of Elektrobit Automotive GmbH (project coordinator), Fraunhofer IIS (Smart Sensing and Electronics; Audio and Media Technologies) and five other industry and university project partners. The SEMULIN project is funded by the German Federal Ministry for Economic Affairs and Energy (BMWi).

🔗 www.iis.fraunhofer.de/semulin-en

1 *Size comparison of the USeP module*

2 *Driver monitoring with various signal parameters in the Fraunhofer test system.*

AI ENHANCES TOOL HANDLING

Sensors provide feedback about the correct execution of work steps

Even in the world of highly automated production, there is still no getting around manual work. On the assembly line, the slightest mistake can severely compromise quality, costs and safety. Our AI experts are using machine learning methods to improve this situation.

"Cognitive Hand Tools" is a research and development project that focuses on using intelligent tool technology to support manual work steps. Smart sensors with embedded intelligence interpret individual movements, rotations, vibrations and sounds to provide direct feedback about correct execution. In this way, they help immediately detect, correct and continuously improve missed or flawed work steps during assembly.

Attached easily to standard tools, the sensor modules are a cost-effective way of making existing tools intelligent.

Thanks to a self-learning algorithm, the sensor modules never stop learning, which means they can be used on all kinds of assembly lines and alongside other tools. So without any major programming or costs, assembly workers can perform their tasks with the aid of intelligent tools.

🔗 www.iis.fraunhofer.de/tooltracking
▶ youtu.be/D3O34GjvGxg

SMART HOME CONNECTIVITY VIA A BASE STATION

LoPAN wireless technology integrates and connects any number of sensors via just one base station

We are all now familiar with the concept of the smart home, in which blinds, heating and windows can be controlled and adjusted at any time via smartphone. To transmit sensor data reliably, most systems require several permanently installed base stations.

But our LoPAN (long-range personal area network) technology allows sensors and actuators located anywhere from the basement to the attic to be connected and controlled via a single base station. The system is scalable and also designed for mobile applications. In this way, LoPAN eliminates all previous compromises for smart home applications.

LoPAN was developed as a robust wireless technology, optimized for long-range use in smart home and smart building applications. The centerpiece of both technology

applications is a telegram splitting method standardized by the European Telecommunications Standards Institute (ETSI). It splits the sensor message into packets and staggers their transmission via multiple frequency bands. This guarantees a high degree of reliability and thus minimizes interference for data transmission.

LoPAN is a lighthouse project carried out at the High-Performance Center Electronic Systems (LZE). The LZE project is funded by the Bavarian Ministry of Economic Affairs, Regional Development and Energy.

🔗 www.iis.fraunhofer.de/pm-lopan-en

AD HOC LOCALIZATION FOR AGILE PRODUCTION

FlexLoc opens up human-machine interaction

The Fraunhofer Cluster of Excellence Cognitive Internet Technologies CCIT has three research centers developing cognitive web-based industry solutions. One of the cluster's three centers is the Research Center IoT-COMMs. This is where we develop localization and connectivity solutions that use cognitive sensors to flexibly self-adapt to agile production and logistics processes.

We developed our FlexLoc (flexible localization) system to enable human-machine and human-vehicle interaction in a production environment. The system uses smart sensor nodes to connect automated guided vehicles with one another or with the operator carrying the corresponding tag. FlexLoc allows us to establish ad hoc localization systems that permit workpieces to be processed with the help of multiple mobile tools. Thanks to ultra-wideband (UWB) localization anchors, which offer precision down to just a few centimeters, the system is scalable as well as flexible.

🔗 www.cit.fraunhofer.de/flexloc-en
▶ youtu.be/WvBX2ax_TWk

WHEN SCREWS "THINK FOR THEMSELVES"

Smart screws increase the safety of bridges and scaffolds

Another IoT-COMMs project is about developing a smart screw connection. It enables wireless and self-powered monitoring of connections on safety-relevant structures such as bridges and scaffolds – without any need for additional infrastructure. A system of sensors uses variations in electrical resistance to measure the preload force on the screw connection and uses the pressure difference to determine whether the screw has loosened. The load data gathered by the sensors is transmitted via the mioty® wireless protocol, with the data transfer from each screw configured and encrypted separately.

Integrating energy harvesting into the mioty® LPWAN technology developed by Fraunhofer IIS paves the way for a self-powered system capable of collecting and transmitting sensor data reliably. The energy required for transmitting the sensor data can be harvested from minor vibrations and minimal shifts in temperature.

🔗 www.cit.fraunhofer.de/screwconnection
▶ youtu.be/lo6IVJc09XM
www.cit.fraunhofer.de/cognitive

1 *AI in the tools supports manual work steps.*

2 *LoPAN offers robust communication for sensor integration in buildings via a single base station.*

3 *FlexLoc connects people and vehicles in warehouses or production facilities.*

4 *The "smart screw connection" is a fully integrated IoT device with self-powered wireless data transmission.*

IOT DEVICE MANAGEMENT MADE SIMPLE

Magnolinq uses smartphone speakers to transmit data for controlling and configuring IoT devices

How do you interact with a device without a user interface? And how do you configure a sensor node that has neither an Internet connection nor space for a wired or optical interface?

Magnolinq is a new near-field communication technology that provides a simple way of mastering these challenges. Similar to RFID or NFC, it sends signals via electromagnetic induction by employing the magnetic coupling of adjacent circuits specifically to transmit data. But Magnolinq offers a particularly clever feature: by using frequencies at the very edge of the human hearing range, the technology can turn any smartphone speaker into a transmitter. This is achieved by way of magnetic coupling between the integrated coil in the speaker and a resonant circuit in the desired device.

With very little effort, this turns smartphones into universal control units, while the receiving device hardware requires only a slight enhancement. Made of tiny standard parts, a simple resonant circuit on the microcontroller is sufficient to receive the magnetically transmitted signals. This makes Magnolinq an especially cost-effective and space-saving option for integrating connectivity into a product.

Using a smartphone to control a Magnolinq-enabled device is child's play: users select the desired commands or configurations in an app or web application, which then transmits them via the phone's speakers to, say, their coffee machine, heating system or exercise bike. This does not require pairing in advance, which makes operation easier – especially in situations with high user turnover. Since the connection is direct, neither sender nor receiver must be connected to the Internet. Magnolinq can also provide a simple way of establishing the initial network connection for IoT devices that do not have a display – a task that has often proved challenging to date.

Manufacturers have the option of first testing the integration of Magnolinq into their products on a prototypical basis. An evaluation kit for this purpose is available from the LZE GmbH online store.

🔗 www.iis.fraunhofer.de/magnolinq-en

UWIN WIRELESS TECHNOLOGY FOR INDUSTRIAL APPLICATIONS

Initial application tests show UWIN wireless technology could replace wired solutions

UWIN (Ultra reliable Wireless Industrial Network) is a wireless technology for real-time industrial communication in demanding environments and application scenarios. Since deterministic cycle times are anchored within the system concept, UWIN is considerably more reliable than Wi-Fi and its response times of under 0.5 milliseconds break even the latest 5G speed records. The technology is also particularly robust: if the chosen wireless channel is occupied by other systems, UWIN seamlessly switches to the next available channel without delay.

These features make UWIN the ideal replacement for wired solutions in the factory, where rotary feedthroughs, sliding contacts and drag chains continue to struggle to compensate for the limited mobility of the subsystems. Adding UWIN to existing production plants is easy with "plug and produce". The technology maximizes this benefit when it comes to wireless control of individual machines or their moving parts.

To demonstrate that UWIN can be a viable replacement for wired solutions, we tested the wireless control of CNC machinery as part of the "Industrial Communication for Factories – IC4F" project funded by the German Federal Ministry for Economic Affairs and Energy (BMWi). In addition, we are currently in the process of testing entirely new applications.

For instance, the Research Center IoT-COMMs, which belongs to the Fraunhofer Cluster of Excellence Cognitive Internet Technologies CCIT, has launched the "SmartTool.connect" project. This involves integrating UWIN directly into a machine's tool holder in order to transmit sensor readings of vibration, temperature, radial runout and speed collected by the rotating tool and thus minimize tool wear.

We are currently working on an evaluation kit for UWIN (EWIN) so that we can quickly roll out future application-oriented projects with industry partners. EWIN comprises a base station and three field devices. The appropriate channels and cycle times can be freely defined via a corresponding user interface in order to check which error-rate, latency and range requirements UWIN is satisfying within a given environment.

🔗 www.iis.fraunhofer.de/uwin

1 Data transmission via speakers turns smartphones into universal control units.

2 UWIN is a technology that supports reliable, real-time wireless control of machines.

TRANSITIONING TOWARD INDUSTRIE 4.0 IN PRODUCTION AND LOGISTICS

The "Technologies and Solutions for Digitalized Value Creation" project combines the economics and analytics expertise of our Fraunhofer Center for Applied Research on Supply Chain Services SCS with the technological know-how of our Positioning and Networks business unit. Together, we are bringing today's production and logistics processes in line with the digital tomorrow.

Technologies and Solutions for Digitalized Value Creation

As we transition toward Industrie 4.0, small and medium-sized enterprises (SMEs) in particular often lack the expertise required to assess and harness the potential that digitalization holds for their operations. It seems as though the hurdle SMEs must clear to implement new technological solutions has been set especially high: perhaps because they have insufficient knowledge to select the right technology and roll it out efficiently; because their employees have yet to acquire the required expertise; or because they are unable to measure the added financial value against investment.

As part of the "Technologies and Solutions for Digitalized Value Creation" project, we help SMEs to develop themselves and their employees toward Industrie 4.0 and to efficiently implement the right solutions. There are various ways of getting started, which enables us to keep the hurdles lower and allow each SME to develop according to its own time frame and rollout plan. We take a four-pronged approach: practical applications, IoT platforms for straightforward data exchange, the human element of digitalization, and Industrie 4.0 organization and management.

« The research work is funded by the Bavarian Ministry of Economic Affairs, Regional Development and Energy as part of the "Technologies and Solutions for Digitalized Value Creation" project. The project is part of the Digital Production topic platform within the BAYERN DIGITAL initiative.

AT A GLANCE

1 | SMEs transitioning toward Industrie 4.0 need help to offset a lack of management, process and technology expertise.

2 | A little goes a long way: Digitalization of selected existing processes and applications.

3 | Technology, management and people: A successful digital transformation hinges on taking a holistic approach to the transformation process.

1 In the "Technologies and Solutions for Digitalized Value Creation" project, we take a holistic approach to researching and supporting digitalization in production and logistics.

1

2
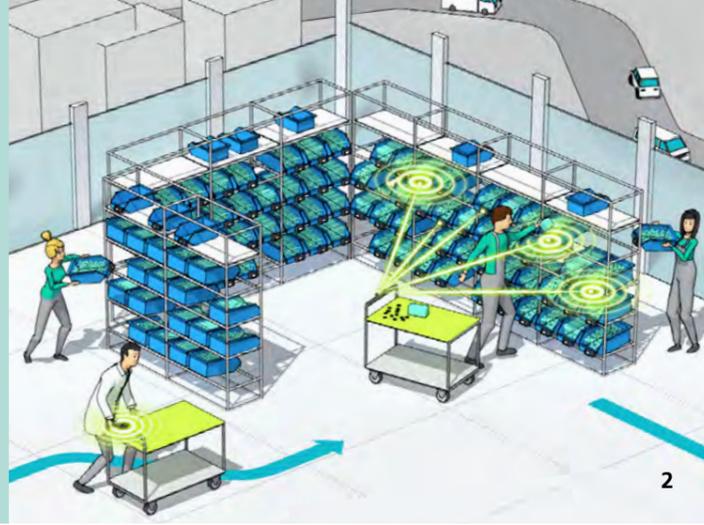
Practical applications: Smart warehouse picking with Pick-by-Light and TRILUM

As part of the project, we identified practical applications relating to container management, in-house transport, use of tools, and picking that lend themselves well to digitalization solutions. In the process, we developed standalone technological solutions that also work on a small scale and are iteratively expandable, making them particularly suitable for SMEs.

A prime example of such an application is the wireless Pick-by-Light system for smart warehouse picking. The system affords flexibility for adding displays to bay compartments, which in turn allows pickup compartments to be reorganized quickly. Further development led to TRILUM, a mobile Pick-by-Light system for voucherless picking and assembly support that we made market-ready.

Application-oriented data platforms for flexible information exchange

Combining different cyber-physical systems (CPSs) to make one large system is difficult thanks to the patchwork of transmission protocols and data formats. Digitalized applications require information to be represented and exchanged via common data formats. This is why we are working on an open message protocol that allows individual CPSs to communicate with each other and thus provides a quick and easy way of solving compatibility issues. Corporate data that exists in different data formats is made available through semantic modeling of the data and workflows that can be interpreted by machines.

An Industrie 4.0 environment generally makes use of centrally controlled digital platforms into which the data is fed. Since there are any number of such platforms, we help companies find the right platform for each IoT use case.

As part of the project, we are also working on a new approach: we are using semantic-web and linked-data technologies to pave the way toward decentralized management and application logic. Such decentralized approaches provide users with consistent and flexible access to all relevant information while the original data owner retains data sovereignty.

How rolling out new technologies affects the workforce

2 The Pick-by-Light picking system and its descendant TRILUM were developed as practical applications as part of the project.

The human element plays a major role in the success and the productivity of Industrie 4.0 technologies and applications. This is why we also look at each phase of digitalization from a behavioral and sociological perspective. After all, the workforce can also object to the implementation of new technologies. This makes it all the more important to uncover resistance factors ahead of time and find solutions to counteract them.

As part of the project, we are not only investigating how new IoT technologies affect the workforce, but also helping answer the question of how to successfully implement technological solutions into operations in a way that enhances motivation and productivity. To this end, we offer a range of services, including training opportunities and individual consulting and coaching sessions.

Organizing data-driven processes and business models

Rolling out new technologies makes economic sense only when they will make business processes more efficient, lower costs or increase sales by adding services. We evaluate companies' business processes and the effects of rolling out the given technology, and we develop new services and business models.

We start by looking at the initial situation to measure a company's digital maturity and work up the required target or future vision. We then build on this to define the necessary changes in terms of technology, activities, actors and organization as well as the challenges that will arise – all leading to new concepts for smart services and business models.

Successfully managing the transition

One of the biggest challenges of the digital transformation lies in managing the process holistically. It is crucial to provide companies with the support they need to quickly and easily start their individual journey toward Industrie 4.0. We lend them our holistic take on the technology and methodology of this transformation so that they can find the financial and organizational means to institute digitalization solutions right away. ∎

www.scs.fraunhofer.de/industrie-4-0

"When it comes to digitalizing production processes, the main problems are organizing the transformation process and managing the transition. Of course it's essential to know and master the technologies involved. But it's just as important to ensure that no one gets left behind."

*Prof. Alexander Pflaum,
Overall Project Management,
"Technologies and Solutions for
Digitalized Value Creation"*

CONTACT

Prof. Alexander Pflaum
Division Director, Fraunhofer Center for Applied Research on Supply Chain Services SCS

Phone +49 911 58061-9515
alexander.pflaum@iis.fraunhofer.de

"SEMANTIC WEB LAB" – CONNECTED DATA SPACE
Making the most of the Internet of Things with semantic modeling and knowledge graphs

If a company wants to utilize data for analysis models, process optimization or business model development, it must make existing data usable and tap into new data. Doing so requires suitable technologies and procedures for collecting, processing and integrating the data. This is where our research into all aspects of connected data space and the Internet of Things comes in.

To ensure companies have quick and flexible access to their data, we are designing – within the production and logistics environment – connected data space based on what are known as knowledge graphs. We also employ rapid IoT prototyping so that companies can access any missing process data as soon as possible. This allows sensor data to be quickly integrated into existing systems, a process that is also based on knowledge graphs.

The next generation of AI applications will be built on knowledge graphs, applications that have flexible data access, connect data automatically and draw logical conclusions. Establishing decentralized management of the data and the processing steps paves the way for integrating new sources, with each company maintaining sovereignty over its data. In addition, the system can be adopted quickly and is resilient to malfunctions. In short, knowledge graphs can help companies establish a future-oriented data platform and thus make more of their data. The research work is funded by the Bavarian Ministry of Economic Affairs, Regional Development and Energy as part of the "Technologies and Solutions for Digitalized Value Creation" project.

🔗 www.scs.fraunhofer.de/dataspaces

AI-SUPPORTED TREND RESEARCH INTO URBAN MOBILITY
Analyzing market and technology trends with NLP and semantic-web technologies

As the mobility transition continues, transport operators and energy providers such as VAG and N-ERGIE face the question of which drive technology will prevail for buses. Are electric buses really the latest trend? Electric buses and the infrastructure that supports them call for massive investment – the buses have a service life of more than a decade. So when companies are drafting their investment strategy, it is important for them to recognize relevant developments early on so that they can avoid making bad decisions. Our data-based trend and scenario analysis provides us with an automated way of tapping all kinds of media sources to infer trends relating to technological developments and market shifts around the world covering a vast array of topics. This means that companies can always be up to speed.

We use AI-supported text processing to identify trends: every week, we automatically collect thousands of communications about electromobility and analyze them to see where reports about test runs and rollouts of battery-powered electric buses are coming from and who is publishing them. Using a combination of machine-based natural language processing (NLP) and semantic-web technologies, we extract the relevant information relating to aspects such as bus manufacturers, powertrain technologies, transport companies and operation sites from the unstructured text media data. Business intelligence tools make it possible to perform specific analyses on an ad hoc basis. This in turn allows companies to base strategic decisions on the facts.

🔗 www.scs.fraunhofer.de/trend-scenario-analysis

"PRODAB": OPTIMIZED LOGISTICS AND PRODUCTION PROCESSES
Detecting delivery delays early on: Analyzing process data and predicting lead times

Disruption to tightly scheduled supply chains often causes problems. At worst, delays in delivering supplier products can even bring production lines to a halt. It follows that shipments that might be delayed should be identified as early in the process as possible. But it is simply impossible to manually track the hundreds of thousands of shipments made each day.

This is where our ProDAB project comes in. Together with three different industry partners, we are examining their internal and intercorporate processes to develop software that can automatically predict both lead times and the filling of buffer stores in logistics processes. This makes it possible to identify early on any shipments that might be delayed. We use Bayesian networks to predict lead times, and neural networks to predict buffers. Based on this statistical modeling, we then have optimum control of the relevant process parameters, including the number of workers or the use of technical tools. In this way, the ProDAB project is enhancing the operational resilience of supply chains.

🔗 www.scs.fraunhofer.de/digitization-transport-logistics

AI PROCESSES: TRANSFERRING FROM SCIENCE TO INDUSTRY
Automated machine learning (AutoML) for industrial applications

There is a big obstacle when using machine learning (ML) for practical applications: identifying the best methods and their ideal configuration – in other words, adapting the existing data situation, processes and application requirements – is extremely complicated and expensive. AutoML promises to remedy this. It harnesses systems that automate the development and configuration of AI processes. Up to now, existing AutoML systems have generally been used in scientific and research contexts because these are geared toward a few standard ML processes and optimized data situations. By way of contrast, it is rare to find such optimum conditions in industrial practice, which explains why limited use has been made of AutoML here to date. With our project, we set out to research how suitable AutoML solutions are for practical use and how they can be transferred to complex industrial applications.

Together with an industry client, we investigated if AutoML systems make sense in an industrial context, if standard systems are sufficient and which specific adjustments would be required to make it worth rolling these systems out. To do so, we performed precision analysis of the state of research, tested the limits and requirements of existing systems and developed our own AutoML system for quality control. We found that specifically configured AutoML systems generally lead to an increase in both performance and output. For this reason, targeted AutoML solutions for special applications are a promising research area for the future.

🔗 www.scs.fraunhofer.de/supply-chain-analytics

NEW LIFE FOR DIGITAL HEALTH TECHNOLOGIES

In the development of digital medicine, Fraunhofer IIS focuses on progression monitoring for people with chronic conditions. During the pandemic, this expertise has proved beneficial to two projects within Fraunhofer's anti-coronavirus program: the pandemic management app for health authorities and the concept for a portable monitoring system for COVID-19 patients on normal hospital wards.

There are only a handful of sectors that prospered during the first year of the pandemic – and digital medicine is definitely one of them. "Both politics and the general population have experienced a shift in awareness about digital medicine," says Dr. Christian Münzenmayer, Head of Image Processing and Medical Engineering at Fraunhofer IIS. "Germany's Digital Healthcare Act (DVG), which came into force at the end of 2019, provided an additional tailwind."

Prescribing apps for chronic patients

Münzenmayer has high hopes for Germany's Digital Healthcare Act because it provides for digital health applications to be covered by health insurance companies. This also includes the technologies that the Fraunhofer IIS team is working on, such as the Digital Patient Manager, or DPM for short. "We're creating a decentralized infrastructure for medical communication," Münzenmayer says. Instead of using a central database, each patient's data is stored on their smartphone or computer. This gives patients sovereignty over their data and means they can decide with whom they wish to share it. The DPM can be paired with apps and sensors that record the condition of people suffering from chronic illnesses. It was created as part of the Mobile Health Lab, which in turn is funded by the Bavarian Ministry of Economic Affairs, Regional Development and Energy.

AT A GLANCE

1 | The coronavirus pandemic and Germany's Digital Healthcare Act are accelerating the development of digital health applications.

2 | Cognitive sensors improve progression monitoring for chronic conditions such as Parkinson's and atrial fibrillation.

3 | A mobile, multimodal monitoring system can improve patient monitoring on normal hospital wards.

"BOTH POLITICS AND THE GENERAL POPULATION HAVE EXPERIENCED A SHIFT IN AWARENESS ABOUT DIGITAL MEDICINE."

Dr. Christian Münzenmayer, Head of Image Processing and Medical Engineering

Most people with chronic conditions go to the doctor only occasionally, usually every three months. They are often largely in the dark about how they are doing in between visits. This is where the intelligent solutions created by the Fraunhofer IIS medical engineering team come in. Essentially, the solutions feature an app that allows each patient to enter information on how they are feeling and what symptoms they are experiencing. This information is supplemented by data from sensors that are specially tailored to their illness. In collaboration with the Universitätsklinikum Erlangen and Portabiles HealthCare Technologies GmbH, Fraunhofer IIS is also working on a solution to help people afflicted with Parkinson's disease. The solution analyzes motion data collected by a sensor integrated into the patient's shoe. Doctors can then use this data to monitor progress in treatment. The Parkinson's project is supported by the EIT Health initiative, which is funded by the EU.

Cognitive sensor technology improves diagnostics for atrial fibrillation

"CardioTEXTIL is an intelligent sensor technology that we're developing for everyday use in cardiology, specifically for people with atrial fibrillation," Münzenmayer says. Around two million people in Germany, Austria and Switzerland suffer from this treacherous form of cardiac arrythmia, which presents sporadically and greatly increases the risk of stroke. To reduce this risk, patients are generally treated with blood thinners. What makes the condition treacherous is that atrial fibrillation often goes undiagnosed and therefore untreated.

CardioTEXTIL is now set to close this diagnostic gap by providing a long-term ECG that takes place over weeks or even months. Fraunhofer IIS laid the groundwork for this development several years ago with its FitnessSHIRT, in which ECG electrodes are integrated into the tight-fitting garment. But unlike the FitnessSHIRT, CardioTEXTIL delivers ECG data of medical quality. The electrodes are integrated into a harness system that can be comfortably worn under normal clothing. On the back of the system is a small electronic device that collects ECG signals and transmits them to a smartphone. In the future, energy-efficient AI processes running on energy-saving embedded processors will analyze the ECG signal within the electronic device itself to detect relevant events. Ten CardioTEXTIL prototypes have already been produced; the team plans to test them on volunteers next year.

Pandemic management app for health authorities

Together with industry partner NeuroSys GmbH, the Medical Engineering department applied its expertise in collecting medical data to develop a pandemic management app for health authorities. "Real contact tracing requires health authorities to inquire daily about health data such as temperature, pulse or symptoms – a job that's now really too big for staff,"

Münzenmayer says. This is where the pandemic management app can make life a lot easier. It is designed to allow each contact person to enter their own data, which is then transmitted automatically to the relevant health authority. Inquiries by phone can then be reserved for cases in which the data indicates a critical progression of the condition.

M³Infekt – Better monitoring of COVID-19

If COVID-19 patients are located on normal hospital wards, their condition can deteriorate rapidly to become life-threatening. However, continuous monitoring of vital signs is available only on intensive care wards. Ten Fraunhofer institutions and four clinics joined forces to develop a monitoring system for this group of patients. In September 2020 they launched the "M³Infekt" project. M³ stands for multimodal, modular and mobile. Multimodal means that the system is equipped with various sensor modules to collect data on parameters such as ECG, oxygen saturation and respiratory rate. Fraunhofer IIS is coordinating the project and its contributions include CardioTEXTIL and AI-based biosignal analysis. "The monitoring system will also benefit people suffering from other serious infectious conditions, such as influenza or sepsis," Münzenmayer says. "The funding we received as part of the Fraunhofer-Gesellschaft's anti-coronavirus program is paving the way for a development that will prove highly relevant even after the current pandemic." ∎

CONTACT

Dr. Christian Münzenmayer
Smart Sensing and Electronics

Phone +49 9131 776-7300
christian.muenzenmayer@iis.fraunhofer.de

PERFECT FIT FOR BROADCAST STUDIOS – PILOT PROJECT IN JAPAN

Transmitting 4K and 8K resolutions in production quality via Ethernet can't be done? Think again! The new JPEG XS video codec was "custom designed" for the migration of broadcast studios and productions to Internet Protocol (IP). Building on JPEG XS, we developed a software-based en-/decoding solution that has come through its baptism of fire as a market-ready solution for production under real conditions. Together with the Japanese broadcaster NHK, we have successfully completed a pilot test for 8K transmission.

The live test – JPEG XS in production

In collaboration with the Japanese broadcaster NHK, we demonstrated the performance capabilities of JPEG XS in a pilot project under live conditions in the fall of 2020. JPEG XS is a video-over-IP codec that has been standardized specifically for production requirements. As Japan is one of the first countries in the world to possess 8K-capable recording and transmission technologies and wants to migrate its broadcasting centers to IP-based systems and work processes, this partner provided the opportunity for a first real test of the use of JPEG XS in professional workflows.

The challenge consisted not only in transmitting 8K in real time, but even more so in demonstrating the synchronicity of JPEG XS under real-time conditions with various compression factors in a real-life broadcast production.

AT A GLANCE

1 | JPEG XS meets the upcoming industry standard for 8K resolution for production-quality video over the Internet Protocol.

2 | JPEG XS offers low latency together with visually lossless image quality.

3 | JPEG XS came through its baptism of fire as it successfully handled real-life 8K applications during a pilot project for NHK in Japan.

1 *The new JPEG XS video-over-IP codec can be used throughout the production/studio process for transmitting resolutions of 4K and 8K in production quality.*

"JPEG XS OFFERS GREAT POTENTIAL FOR VIDEO-OVER-IP TRANSMISSION IN THE BROADCAST STUDIO – FROM THE SENSOR TO PLAYOUT."

Prof. Siegfried Fößel

JPEG XS can also be used throughout the production/studio process. This eliminates the need to use various transmission formats such as the SDI (serial digital interface) standard for video transmission, which saves time, materials and money. When building or converting modern broadcast centers and studios, JPEG XS is suitable for a wide variety of applications and guarantees high compatibility with other work processes that have already made the switch to IP transmission.

Development from a distance and under pandemic conditions

Many of the consultations, advance development work and meetings were carried out on a purely virtual basis – not just for reasons of geographical distance, but above all because of the first looming signs of the current pandemic, which in January and February were still very uncertain. For our employees, this was not necessarily anything new, but all the same it was no easy undertaking to schedule meetings over various locations and time zones and make sure that the work discussions were productive and clear and led to good results. Despite the challenges, however, cooperation with the Japanese partners was characterized by timely and constructive contributions. Before the worldwide lockdown, as acceptance of the JPEG XS implementation and a few adjustments were due to be carried out, one of our chief developers worked on-site with the Japanese team. Under strict hygiene rules that applied to this visit, including during the work itself, the chief developer was comprehensively supported by the Japanese team and made to feel welcome, such that he was able to smoothly and quickly implement the required alterations.

JPEG XS – a codec "custom made" for production

JPEG XS is characterized by its universal applicability and is standardized (ISO/ IEC 21122). This is one of the outstanding features that makes JPEG XS such a promising development for many different kinds of production applications. It allows high image resolutions of 4K and 8K to be transmitted via conventional Ethernet connections with a frequency of 60 to 120 Hz. As a low-complexity codec, the big advantage of JPEG XS is the low latency for things like hardware implementations: 32 lines end to end. This opens up application opportunities for camera and monitor integrations with high image quality, for integration into studio and production sets and for virtual reality applications and gaming. JPEG XS makes it possible to transmit visually lossless images at compression rates of up to 10:1. To this end, we have developed software for CPU-optimized en-/decoding of high-resolution images. This software is also available as a software development kit.

Does this represent the end of the road for its potential?

Ongoing standardization work points toward an expansion of the applicability of JPEG XS into fields such as high-resolution professional cameras. We are currently collaborating with further standardization partners on a method for compressing raw Bayer image data that will allow the original camera data to be retained for further image processing steps in post-production.

This will make it possible to use JPEG XS from the sensor to the playout of the image data, both in cameras and on the transmission path. ∎

www.iis.fraunhofer.de/jpegxs

CONTACT

Prof. Siegfried Fößel
Audio and Media Technologies

Phone +49 9131 776-5140
siegfried.foessel@iis.fraunhofer.de

1

2

SUCCESSFUL YEAR FOR FOURTH GENERATION OF AUDIO CODECS
Renowned licensees opt for MPEG-H, xHE-AAC, EVS and LC3/LC3plus

Building on the success of three earlier generations (mp3, AAC and HE-AAC), we are making rapid progress in the commercial deployment of our fourth-generation audio coding processes. In 2020, numerous new licensing agreements were concluded. One notable example is with semiconductor manufacturer NXP, which in March licensed a comprehensive MPEG Audio codec suite from Fraunhofer IIS that includes xHE-AAC and MPEG-H Audio. Last year also saw numerous other successes for our fourth generation of audio codecs (MPEG-H, xHE-AAC, EVS, LC3/LC3plus).

The first MPEG-H-based 360 Reality Audio music streaming services went online, offered by the likes of Sony Select, Tidal, Deezer and Amazon Music HD. This coincided with Amazon's launch of its Echo Studio smart speaker, which incorporates Fraunhofer IIS's MPEG-H Audio decoder software. Other new MPEG-H licensees include Sound United, which upgraded various AV receivers from its Denon and Marantz brands with MPEG-H 3D Audio in November, and McIntosh Laboratory, whose MX123 AV processor now supports the format as well. We were also pleased to announce the licensing of Fraunhofer IIS MPEG-H Audio patents to major Korean consumer electronics manufacturer Samsung. In addition, we launched the new MPEG-H 3D Audio Baseline Profile, which, as a subset of the existing profile, significantly reduces the implementation and testing effort. The latest digital audio signal processors from our long-standing customer Analog Devices already support this profile.

To provide content creators in TV and streaming even greater support with their production of MPEG-H audio content, we made two new tools available for download in 2020. The first is the ADM Info Tool, which helps create Audio Definition Model (ADM) metadata, and the other is the MPEG-H Authoring Suite (MAS). Comprising several applications, the MAS software package enables easy, fast and intuitive production

of MPEG-H Audio content. We also released supplementary video tutorials on live production using MPEG-H Audio and on post-production using the MPEG-H Authoring Suite, and held several webinars attended by hundreds of TV and streaming professionals from around the world.

Meanwhile, 2020 saw many other providers begin to use the xHE-AAC audio codec for mobile streaming. Prime among the new licensees of the Fraunhofer xHE-AAC and MPEG-D DRC software implementation is Microsoft. For its part, Apple showcased the benefits of the latest generation of the AAC codec family on its devices at the 2020 Worldwide Developer Conference. Last but not least, the streaming service Netflix has been using the xHE-AAC audio codec on Android mobile devices since January 2021.

Market penetration of EVS, the 3GPP standard codec for 4G and 5G telephony, has also increased. Most recently, several mobile providers in Asia have integrated the technology into their networks. The Low Complexity Communication Codecs (LC3 and LC3plus), which now extend EVS quality to all communication platforms, have experienced a high volume of license requests since their official launch. In January, Bluetooth® SIG announced LC3 as the standard audio codec for Low Energy Audio and finally adopted the specification in September 2020. In the meantime, Microsoft, Cadence and Broadcom are among those to have become licensees of Fraunhofer's implementation of the LC3 codec. Its sibling LC3plus, which is equipped with numerous additional features, had already been standardized in 2019 as ETSI TS 103 634 and was included in the 2019 DECT standard. In 2020, the first product for end consumers with LC3plus was launched: the W59R DECT phone from Yealink.

www.xhe-aac.com
www.mpeg-h.com
www.iis.fraunhofer.de/lc3

ALL EARS FOR UPHEAR AGAIN IN 2020
Streaming camera and smart speaker featuring upHear microphone technologies

Fraunhofer's upHear signal processing solutions significantly improve the quality of sound recording and playback from both professional and consumer devices. The new Mevo Start streaming camera incorporates Fraunhofer IIS upHear Spatial Audio Microphone Processing technology to ensure it delivers top-quality audio recordings. For interviews and livestreaming from home, upHear enables the camera, set to voice mode, to extract the desired voice recording, while suppressing other noises to ensure good intelligibility at all times. In concert mode, the camera can capture immersive audio experiences at live events – even with its very compact microphone arrangement.

Mail.ru Group, a major Russian online services provider, has equipped its first smart speaker, Capsula (Капсула), with Fraunhofer upHear Voice Quality Enhancement (VQE). The technology optimizes the microphone signals picked up by the device's microphone array and, in smart assistant mode, provides a clean speech signal to the Mail.ru voice assistant Marusia (Маруся). In communication mode, the full-duplex communication functionalities of upHear VQE ensure the best possible audio quality for voice calls.

www.uphear.com

1 The new Mevo Start streaming camera delivers the best possible audio quality in its recordings thanks to Fraunhofer upHear Spatial Audio Microphone Processing.

2 Fraunhofer upHear VQE's full-duplex communication functionalities ensure the best possible audio quality for voice calls using Mail.ru's Capsula smart speaker.

SAY GOODBYE TO FRUSTRATION AND HELLO TO SUCCESS!

"Artificial intelligence?" – "Sure, I've heard of it" is a common reaction. But companies are often at a loss as to how they can profitably use AI technologies. Our scientists give businesses a helping hand in a consortium project that offers numerous advantages.

Artificial intelligence (AI) is a key factor determining the success of companies today. When you put your ear to the ground, however, you quickly discover that only a small minority knows what it really is – in place of factual knowledge, there are a lot of misconceptions doing the rounds. And things get even trickier when it comes to the concrete question of how to use artificial intelligence to solve a company's individual issues in a targeted and effective manner. As a result, businesses often end up choosing unsuitable or overly complicated applications when looking to use AI – leading to frustration rather than the success they were seeking. In many cases, this leaves the potential of AI unexploited.

Getting from an airy buzzword to specialist knowledge, methodological expertise and concrete implementation

Scientists at Fraunhofer IIS's Engineering of Adaptive Systems division EAS have embraced the goal of changing this unfortunate situation and allowing companies to tap the benefits of artificial intelligence by means of a consortium project that was launched on September 16, 2020 and was founded in conjunction with KEX Knowledge Exchange AG. "Through the consortium project, we want to pull artificial intelligence down out of the buzzword clouds and make it tangible and usable for our partners – after all, the employees in the companies rarely come

AT A GLANCE

1 | Companies often struggle with the concrete application of artificial intelligence. How can they profitably apply it to their business concerns?

2 | The consortium project helps them get started and transfers expert knowledge to the companies.

3 | It kicks off with the fundamentals of artificial intelligence and ends with a roadmap and specific implementations.

1 *In the "AI: Understand – Apply – Benefit" consortium project, 20 partners jointly elaborate implementation opportunities for AI in their companies.*

"OUR CONSORTIUM PARTNERS ALWAYS HOLD THE REINS."

Toni Drescher

from an AI background," says Anne Loos, Head of Business Development at the Engineering of Adaptive Systems division EAS. The project has attracted a lot of interest in the industrial sector, with 20 companies signing up to participate, ranging from small businesses and SMEs to large corporations. There is also a lot of diversity in terms of different sectors.

The project comprises three phases. To begin, there is foundational training: "There's a tendency to think of artificial intelligence as something you turn to when you reach the limits of your own capabilities," Loos says. "But that's actually way off the mark: AI can't always solve problems for which we ourselves don't yet have a solution. But it does help us speed up complex procedures and relationships – provided we've described them first." That is to say, the true core of artificial intelligence is the training phase, during which expert knowledge is represented in the AI. Only when the system has been trained in this way can AI take a step beyond and learn things independently.

It is important to convey these and other fundamentals to the participants before getting down to the nuts and bolts. "We deliberately go into companies to align expectations with reality. What problems and tasks do you want to solve using artificial intelligence? What do the underlying processes look like? How mature is the company's planned use case for AI?" summarizes Toni Drescher, CEO of KEX AG. After learning the basics, participants take part in a technology study, in which the project team starts out by identifying concrete solution options that suit the use cases they have elaborated together with the industrial partners. At the beginning of the third phase, the companies jointly select preferred use cases that are to be implemented as prototypes in the further course of the project. "As such, our consortium partners always hold the reins," Drescher says.

When initial applications have been found, the researchers prepare them for the companies. For example, what "homework" still needs to be done? In regular meetings, the project team presents the various use cases in the consortium – in anonymized form of course. In this way, the participants gain a good overview of where AI can be used effectively, including in areas outside their own immediate sphere of concern. They can discuss the various applications and learn from each other and from the various use cases.

At the end of the project, the participants are presented with concrete roadmaps laying out how AI can be implemented in their company. They also bring home the requisite know-how: in a five-day intensive training course at the end of the project, the project team teaches them deeper knowledge about artificial intelligence, thus transferring technological knowledge into the companies.

And now to the question that companies will probably be most interested in: What advantages does participating in the consortium project offer them? Several answers spring immediately to Loos's mind: "In the consortium project, which will be running until June 2021, the companies gain the opportunity to evaluate the use of AI for their use case from a commercial and technical perspective. Moreover, they obtain individual access to the latest knowledge, technologies and applications relating to AI – and all this for a relatively low price." The companies can incorporate their very individual requirements into future AI research projects and so accelerate their own AI process development. They gain access to a network of AI experts along with ideal opportunities to expand the AI expertise of their employees. In short, they learn to leverage the advantages of artificial intelligence in a highly targeted manner for their company. ∎

🔗 www.eas.iis.fraunhofer.de/consortium-project-ai

CONTACT

Anne Loos
Engineering of Adaptive Systems division EAS

Phone +49 351 4640-807
anne.loos@eas.iis.fraunhofer.de

#WeKnowHow

USING AI TO AVOID BOTTLENECKS IN MEDICAL SUPPLIES
Early detection system helps plan, manage and control resilient value chains

The coronavirus crisis has driven the lesson home: the extraordinary medical emergencies brought on by the pandemic have led to shortages in urgently needed medical supplies. Global trade restrictions and long delivery times for medical equipment have exacerbated the situation – particularly given that hardly any personal protective equipment (such as gloves, protective gowns and masks) is manufactured in Germany.

To avoid such scenarios in the future, our Engineering of Adaptive Systems division EAS is supporting a project team led by KEX Knowledge Exchange AG that is developing an early detection and prediction system for the medical sector. The aim is to identify supply bottlenecks early on, so that suppliers, distribution points and medical facilities can take action in good time. This will ensure the sustainable, cost-effective supply of necessary items and, more generally, make supply chains resilient to market fluctuations.

In the "corona.KEX.net" AI lighthouse project of the state of North Rhine-Westphalia, we are primarily working on one of the core functionalities: the AI-based early detection system for consolidating volumes and calculating safety stock levels. This is based on a model that forecasts current and future demand for bottleneck products and derives a safe level of inventory from these projections. The system is designed to detect deviations from optimum inventory levels and provide an early warning whenever the current or future risk of shortages is high. This allows medical facilities to respond to the situation in good time.

We are refining AI algorithms for this functionality and training them with various data such as infection rates, capacity utilization and relevant production metrics. These algorithms will support flexible management of safety stocks in distribution centers and warehouses. In addition, we calculate various forecasts required for the products, such as demand, delivery quantity, delivery time or price. And it is essential to develop the right strategy for procuring and maintaining safety stocks. Finally, regular stress tests will be conducted to optimize the early detection system's resilience. The "corona.KEX.net" project is sponsored by the German state of North Rhine-Westphalia.

www.eas.iis.fraunhofer.de/corona-kex-net-en

1 *North Rhine-Westphalia State Minister for Economic Affairs and Digitalization Prof. Andreas Pinkwart hands over the funding notification for the corona.KEX.net project, in which Fraunhofer IIS/EAS further develops and trains AI algorithms.*

2 *Prof. Bernhard Grill, Prof. Albert Heuberger and Prof. Alexander Martin (from left to right), the three Institute Directors of Fraunhofer IIS, are forging paths on the way to sustainably positive digitalization.*

#WeKnowHow

HOW FRAUNHOFER IIS IS MEETING THE CHALLENGES OF THE FUTURE

We develop and use artificial intelligence and steer digitalization in a sustainable and human-friendly direction. In the interviews below, the three Institute Directors describe how, in pursuit of this objective, we consider the entire chain, from the capturing and initial processing of data, to the analysis, deployment and exploitation of the data, to direct interaction between human and machine.

Prof. Albert Heuberger,
Executive Director

How do we deploy AI directly at the sensor?

Albert Heuberger: Our goal is to obtain information of optimum quality from sensor systems. Near-sensor AI allows us to make adaptive adjustments to the sensor, which yields data of much higher quality than provided by conventional sensor systems. Above all, AI-supported sensor systems will be much easier to integrate and to operate. The system will take many work steps off the hands of users and help them with tasks such as making the right settings.

How can neuromorphic hardware increase the performance capability and energy efficiency of entire systems?

Neuromorphic hardware is modeled on neurobiological architectures, enabling it to simulate neural networks in integrated circuits. The computing of data runs parallel in distributed memory units, which also eliminates the time-consuming transfer of data between execution unit and memory. This makes neuromorphic chips much faster and more energy efficient than the processors used before. As a result, it becomes possible to implement complex AI algorithms on mobile, battery-operated devices.

How can next-generation computing help digitalization succeed in Europe?

The current digitalization push involves large data volumes and significant energy consumption. With next-generation computing, we want to develop hybrid, secure computer technologies that are used either individually or complementarily, depending on the problem at hand. This will help maintain and expand research expertise and technological sovereignty in Europe.

Prof. Bernhard Grill,
Institute Director with responsibility for audio and media technologies

Where do problems exist that traditional methods can't solve, and how can AI be of help?

Bernhard Grill: Above all else, AI is the further development of tools. We've already identified numerous applications and issues where traditional approaches to identifying a solution are reaching their limits, but where AI methods have delivered very promising results; one good example is signal processing. For instance, we managed to use AI-based methods to solve a dilemma faced by broadcasting stations: How do you create the best sound for a TV broadcast? With our AI-based dialog separation, people at home can use their remotes to decide for themselves how loud the dialog should be and how loud the background should be.

Looking at technological developments in the workplace, how can we place humans front and center in their jobs?

For me, it's about building machines that make people's lives even easier. Although in essence, it's also about getting machines to do even more of the boring, mindless tasks so that people don't have to. Our contribution will be to develop important components for such future technological solutions.

Fraunhofer IIS is also doing work on speech interfaces. What is the vision behind this?

In the future, we expect every device that is in any way operated will have voice control technology. However, the solutions available today are still far from ideal. In collaboration with Fraunhofer IAIS, we're developing a voice assistant platform that combines our know-how in the domain of audio and voice signal processing with Fraunhofer IAIS's experience in the domain of speech interpretation/evaluation. The result will be a system that is more flexible, easier to adapt and more secure.

Prof. Alexander Martin,
Institute Director with responsibility for research into positioning and networks and into supply chain services

How do we achieve high data quality?

Alexander Martin: Data is the raw material of AI: the higher the data quality, the better the AI. To achieve high data quality, heterogeneous data offers an advantage. In the coronavirus pandemic, for example, the data of individual countries is less useful as regards making predictions than the collected datasets of various countries.

How can we make AI applications sustainable?

The sustainability of AI applications refers both to the data and to the hardware. Data collection and storage generates sizeable and growing volumes of CO_2 emissions, but so does the operation of hardware. Handling data in a resource-efficient manner means looking at data in terms of its entire life cycle. Sustainable and "green" IT systems – sometimes called "green ICT" – consume less energy and use resources responsibly.

How do we achieve European AI sovereignty?

It's a matter of establishing a federal system for data supply and for data management, which suits Europe's style of federalism much better than the United States' purely capitalist model or China's centralized system. A federal system ensures optimum cooperation across country borders while also guaranteeing regional sovereignty over data. ∎

"AS MUCH AS I RESPECT THE CHALLENGE OF THE TASK AHEAD, I'M ALSO LOOKING FORWARD TO IT."

Dr. Norman Uhlmann

DR. NORMAN UHLMANN TAKES OVER THE REINS FROM PROFESSOR RANDOLF HANKE

Since October 1, 2020, the physicist Dr. Norman Uhlmann is heading the Development Center for X-ray Technology in Fürth

The new division director is a familiar face: doctor of physics Norman Uhlmann has been an important part of the team at the Fraunhofer Development Center for X-ray Technology EZRT for 13 years. From 2010, he headed the Application-Specific Methods and Systems department there; and from 2015, he additionally held the position of deputy division director. "Not only do we have state-of-the-art technology and smart people, but also optimum conditions in the working environment, which in my view are the most important ingredients for success. This includes a great workplace culture, shared values and respectful interactions with each other. Only by having these things in place can you unlock your team's creativity and abilities," notes Dr. Norman Uhlmann. With the development of prototype systems in particular, Uhlmann is building on a business model that has made the division very successful over recent years. But the digital transformation is also central to his plans. He considers it important to mine useful information from raw data readings and link it with corresponding metadata and data from other sources. By doing this, Fraunhofer EZRT can give customers the best foundation for making informed decisions. To this end, the staff at the EZRT are also in close contact with their colleagues at Fraunhofer SCS.

Professor Hanke stays on as deputy director of the institute

After over three decades at the institute, Professor Randolf Hanke has handed over his position as division director to his successor. He is staying on at the institute as deputy director. In 1989, Hanke started out his career at Fraunhofer IIS as a physics graduate. In 2001, he was given one of the highest distinctions within the Fraunhofer-Gesellschaft: for his research work on an intelligent system for automated X-ray inspection, he was awarded the Joseph von Fraunhofer Prize. In 2013, the EZRT moved into its brand new building in Fürth-Atzenhof, which was constructed under Hanke's leadership. The XXL computed tomography system and an additional 20 systems housed there offer researchers and industrial customers a machine park that is unparalleled anywhere in the world.

Dr. Norman Uhlmann is now responsible for the systems and the staff at the four Fraunhofer EZRT locations at Fürth, Würzburg, Deggendorf and Passau. "As much as I respect the challenge of the task ahead, I'm also looking forward to it," the new division director says.

1 *Dr. Norman Uhlmann (left) took over as division director from Prof. Randolf Hanke as of October 1, 2020.*

1

Keys to tomorrow
Forward-thinking strategies and projects
are paving the way to a bright future

"IN MY VIEW, SAXONY HOLDS ALL THE ACES FOR FURTHER EXPANDING ITS POSITION AS AN ARTIFICIAL INTELLIGENCE HUB."

Dr. Peter Schneider

ARTIFICIAL INTELLIGENCE IN DIGITAL SIGNAL PROCESSING

Fraunhofer IIS combines digital signal processing with artificial intelligence in a center for consulting and licensing and for creating special customized solutions

Today's consumer electronics, automotive technology, telecommunications and intelligent assistance systems would be inconceivable without digital signal processing. Now we are taking the logical next step by using machine learning and artificial intelligence to advance these fields of application even further. This will allow us to find solutions for problems in our core competence domains that would not be obtainable through purely digital signal processing. In view of the general significance of signal processing and AI across various applications, it is essential for Bavarian companies to be able to access excellent basic technologies for their products.

To ensure that they can, Fraunhofer IIS' Center for Digital Signal Processing using Artificial Intelligence (DSAI), brings together all relevant knowledge under one roof. The DSAI adresses the three commercially significant topic areas in which Fraunhofer IIS has its core competencies: computer vision, voice signal processing and signal processing for data transmission.

SAXONY ELABORATES AI STRATEGY

Study by Fraunhofer IIS/EAS serves as basis for development process

The Free State of Saxony is working hard to expand its position as a leading location in the domain of artificial intelligence (AI). An AI strategy is an important milestone on the road to achieving this goal, and in the summer of 2020 the State Chancellery launched an elaboration process for just such a strategy. Together with participants from business, science, research, trade associations and the general public, the Free State plans to present its AI strategy as a roadmap by the end of the first half of 2021.

The starting point and foundation of this process is the "Artificial Intelligence – Expertise and Innovation Potential in Saxony" study published by Fraunhofer IIS's Engineering of Adaptive Systems division EAS. In a comprehensive evaluation, it sheds light on how companies and research are positioned with regard to AI and the hurdles they face. In addition, it outlines a series of possible actions they could take.

Dr. Peter Schneider, Division Director of Engineering of Adaptive Systems EAS, emphasized during the kick-off event:

"IF WE'RE TO CONTINUE TO BE ABLE TO LEVERAGE SIGNIFICANT COMPETITIVE ADVANTAGES WITH OUR AI OFFERS IN THE FUTURE, WE MUST MAKE THE EXCHANGE AND TRANSFER OF KNOWLEDGE BETWEEN RESEARCH, TEACHING, BUSINESS AND POLITICS EVEN MORE EFFICIENT – AND ABOVE ALL STRUCTURE IT ON THE BASIS OF RECIPROCITY."

Study names fields of action

The study also pointed out additional fields of action. One of the greatest challenges for industry and science in the development and deployment of AI is the shortage of skilled workers. Other issues cited by the respondents as important include the reliability of AI decisions, employee qualifications and the ability to access large amounts of data. Meanwhile, the comparatively decentralized structure of the economy and its start-up culture also have an influence on the speed of AI developments.

The study is based on the results of a project of the same name conducted in 2019, on which the Engineering of Adaptive Systems division EAS collaborated with TU Dresden. In this project, the partners carried out expert interviews and organized workshops and roadshows with companies that offer AI and with people working on applications and research. The project was funded by Saxony's State Ministry of Economic Affairs, Labor and Transport as part of its technology promotion program.

"KITE": USING AI TO REDUCE TRANSPORT EMISSIONS

AI-based method for route planning brings greater sustainability to transport logistics

One of the big challenges in dealing with climate change is how to reduce greenhouse gas emissions in transport. In commercial freight traffic in particular, there is significant potential for reducing emissions. After all, a substantial proportion of truck journeys are not loaded to optimum capacity. In the KITE project, our researchers are collaborating with project partners Optitool GmbH, BLG Logistics Group AG & Co. KG and Schmahl & Stoepel GmbH to develop a new AI-based method for route planning. Our goal is to reduce empty runs and make transport logistics more sustainable.

To do this, we are combining machine learning algorithms for forecasting freight volumes with mathematical optimization for route planning and using this approach to expand existing solutions for route planning optimization. By contrast, previous methods are generally able to take only fixed orders into account. Yet good transport schedulers often want to improve the route framework even more by acquiring further orders in a targeted manner, offering or accepting trips on freight exchanges, deferring tours or rejecting trips entirely. In the future, the KITE software will help with these four options by giving intelligent recommendations for action. For example, the algorithm could suggest calling up a certain existing customer who probably has demand and whose order suits the tour. The objective is to reduce the empty runs of the companies involved by up to 15 percent.

🔗 www.scs.fraunhofer.de/digitization-transport-logistics

ELECTRONICS YOU CAN TRUST

Projects for the development of functionally secure and trusted integrated circuits and systems

For electronics to be reliable, it is becoming increasingly vital to protect them from outside attacks. To this end, the providers and integrators of microelectronics need to be able to trace their manufacture and inspect their functions.

"Trusted electronics and data security are the basis for all digital, connected systems – especially for the Internet of Things, but for AI too," says Prof. Albert Heuberger, Executive Director of Fraunhofer IIS. As such, trusted computing comprises not only tamper-proof hardware and reliable software, but begins with secure semiconductor production, continues with non-readable memory contents and secure computer identities, and ends with secure embedded systems.

Fraunhofer IIS is helping establish the Fraunhofer Center for Trusted Electronics as part of the High-Tech Agenda of the Bavarian State Government. At the Engineering of Adaptive Systems division EAS, moreover, we are working on various projects within the German flagship "Trusted Electronics" initiative.

Here, we want to explore questions such as how hardware can be transformed from an Achilles heel into a bedrock of trustworthiness, through suitable planning at the design stage of the electronics at the architecture level and making sure this is implemented for all subcomponents. We also want to help protect intellectual property along the value chain of microelectronic components and systems by means of innovative methods in design and testing.

The projects benefit from our expertise in the field of design methods for safe and reliable integrated circuits and systems, which includes our know-how in areas such as grey box verification and the development of a trustworthy design process for the automotive sector. On top of this, we contribute our know-how in the area of IC design flow.

Not only are we thus developing a design process for distributed production, but by facilitating the independent manufacture of individual system components we are also protecting intellectual property in general.

🔗 www.eas.iis.fraunhofer.de/trusted-electronics-en

RESILIENCE: DEALING WELL WITH CRISES

How our app and security concept are making businesses more resilient in times of crisis

The COVID-19 pandemic has hammered home the importance of resilience. Research has two jobs here: on the one hand, it has to quickly find answers to new challenges in cases of emergency – such as with the development of the coronavirus warning app (see article on page 7); on the other hand, it needs to develop strategies to put businesses and society on a more resilient footing for future crises – for example, by making supply networks more stable and secure. We are working both of these angles with two corresponding concepts.

Friendly neighbors 2.0 – "INSELpro"

In the INSELpro consortium project, we are developing a digital service concept for a new kind of neighborhood assistance in urban areas. A neighborhood app that connects residents is being created for a Nuremberg city district.

The app puts people who need services in contact with people who provide them. It includes typical community services such as shopping, repairs, bureaucratic appointments, nursing/childcare and shared leisure activities. Users can take up offers and make offers themselves. We are developing the mediation back end, including an algorithm that enables optimized access and the straightforward placing and brokering of offers in real time within the app.

Resilient cash logistics: "BaSic" security concept for emergency and crisis cases

The intact circulation of cash is vitally important so that people can procure their basic needs. It could transpire, however, that various crisis situations disrupt this circulation and that the electronic means of payment so widely used today cease to work. This is precisely where the BaSic consortium project comes in.

For the first time, banks, trading companies, cash transport companies and research institutes are developing a holistic security concept that is designed for the long term and takes into account all the players involved and their needs.

For specific scenarios, our researchers define the optimum cash delivery by way of mathematical optimization. Not only do they indicate which data needs to be available for an optimization in the respective crisis situation, but they also calculate the optimum control of cash distribution based on cash withdrawal behavior in the crisis situation. This guarantees the availability of cash and transport resources in emergency situations on a supra-regional level.

🔗 www.scs.fraunhofer.de/supply-chain-analytics

INSTITUTE PROFILE - FRAUNHOFER INSTITUTE FOR INTEGRATED CIRCUITS IIS

The Fraunhofer-Gesellschaft, headquartered in Germany, is the world's leading applied research organization. Its research activities are conducted by 75 institutes and research units at locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of 29,000, who work with an annual research budget totaling more than 2.8 billion euros.

The Fraunhofer Institute for Integrated Circuits IIS, headquartered in Erlangen, Germany, conducts world-class research on microelectronic and IT system solutions and services. Today, it is the largest institute of the Fraunhofer-Gesellschaft.

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. Any mobile phone you buy today, for instance, uses audio technology developed by the institute, while Fraunhofer codecs provide the basis for sound of more than half of all TV broadcasts worldwide and almost all radio and streaming services. The institute's professional tools for digital film and media production are also being used globally.
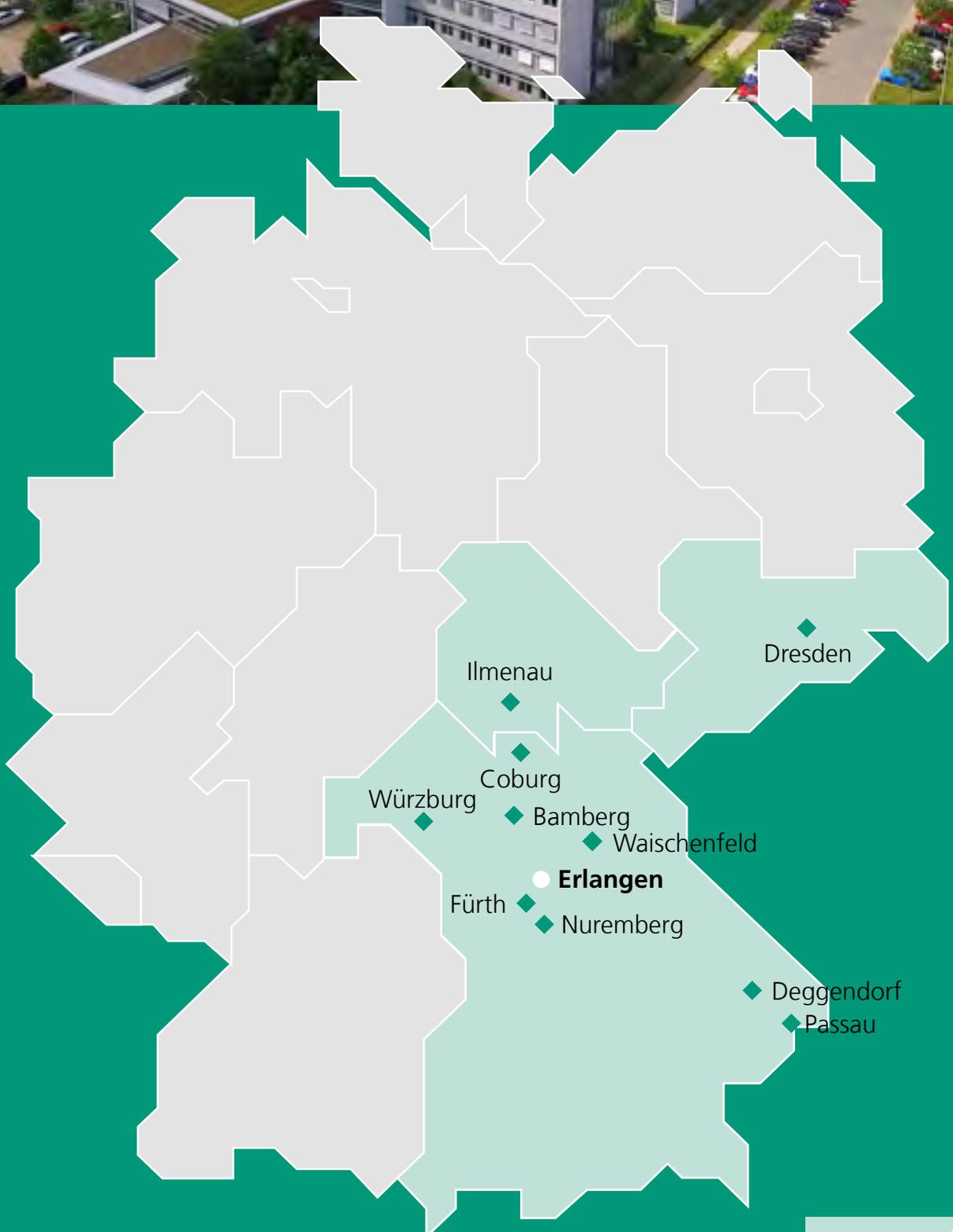
In the context of **"Cognitive Sensor Technology"**, the institute researches technologies for sensor technology, data transmission technology, data analysis methods and the exploitation of data as part of data-driven services and their accompanying business models. This adds a cognitive component to the function of the conventional "smart" sensor. The results of this research have been applied in the areas of connected mobility, communication and application solutions for the Internet of Things, digitalization of human sensing, product and material monitoring, and business analytics in supply chains.

More than 1100 employees conduct contract research for industry, the service sector and public authorities. Founded in 1985 in Erlangen, Fraunhofer IIS now has 16 locations in 12 cities: Erlangen (headquarters), Nürnberg, Fürth and Dresden, as well as Ilmenau, München, Bamberg, Waischenfeld, Coburg, Würzburg, Deggendorf and Passau. The budget of 167.9 million euros a year is mainly financed by contract research projects. 29 percent of the budget is subsidized by federal and state funds.

Erlangen, Germany; March 2021

www.iis.fraunhofer.de/profile

Dresden

Ilmenau

Coburg

Würzburg

Bamberg

Waischenfeld

Erlangen

Fürth

Nuremberg

Deggendorf

Passau

Headquarters ●

Locations ◆