Fraunhofer

INNOVATION for our FUTURE 2025

Our highlights at the Fraunhofer joint booth will offer you new technologies and solutions in the areas of

- Edge AI
- Sensor Technologies and Systems
- Efficient Sensor Communication
- Green ICT

Topics

Fraunhofer@ew25: Innovation for Your Future

Sensor Technologies and System Measurement, Efficient Sensor Communication, Edge AI, and Green ICT

We talk Edge-AI! You, too? If so, let´s plan and realize cutting-edge Edge-AI technologies and solutions that will increase the performance, sustainability and efficiency for a lot of industrial, medical and automotive applications. We provide a wide range of technologies, solutions and possibilities for enterprises to build-up Edge AI know-how in their facilities to steer their processes by themselves.

Another challenge the whole embedded community has to face is the sovereignty of technology and to secure supply chains and technology access. With the Bavarian Chip-Design-Center we provide an important milestone for these issues: Chiplet technologies and implementation, ASIC and IC design that are focused on customer- and application-oriented requirements as well as energy-efficiency and sustainability on top.

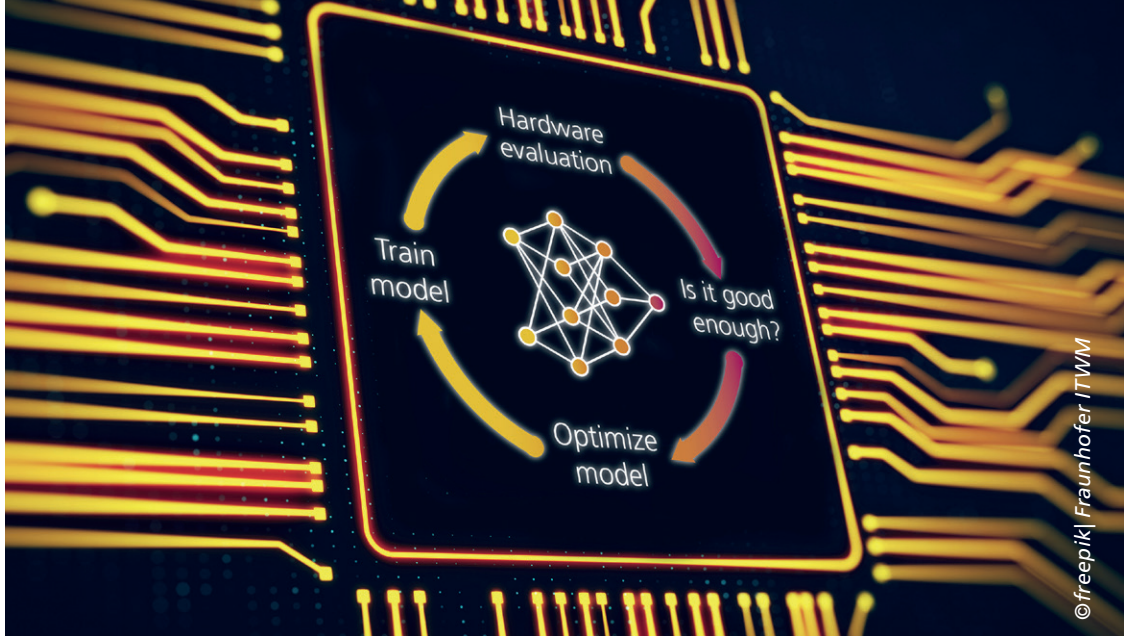
With our future-proof Low Power Wide Area Network LPWAN mioty® e. g. we set new standards in the field of wireless data transmission in terms of scalability, cost efficiency, range, transmission security and battery life.

Mobile ad-hoc networks for reliable communication in robot or drone fleets will increasingly influence the way how we work in our industries. And digital twins and simulation for virtual test benches help e. g. to validate off-road applications.

If we have aroused your curiosity to learn about these new possibilities – then we look forward to your visit and your questions. Enjoy reading it!

Fraunhofer Joint Booth
Hall 4-422

Neural Architecture Search is the Enabling Technology for Edge AI



The data produced at the edge brings many opportunities for novel AI applications. Since the volume of produced data is increasing steadily, we observe a shift away from the cloud and towards the edge for AI processing. But implementing AI on the edge is challenging, since computational resources are limited. Common manual finetuning of the models is not able to keep up with the demand. Human experts become the bottleneck for edge AI adoption. Neural Architecture Search automatizes AI design and makes AI adoption widely applicable and scalable.

Data produced at the edge often is send to the cloud for processing. This approach is running into two major bottlenecks:
1) The energy bottleneck, since the energy consumption of datacenter grade hardware is high.
2) The communication bottleneck, since moving all generated data into datacenters for processing is hitting a bandwidth limit.

Edge AI is a smart way to process data efficiently at the source, so that both the energy and communication bottleneck can be resolved. However, doing so is challenging, since designing edge AI applications requires to consider both the application performance and the hardware limitations. Human experts are needed to design edge AI models, but these manual design processes become the bottleneck for edge AI adoption.

Neural architecture search makes edge AI design scalable

Neural architecture search (NAS) is a method to automatically find good AI models. More specifically, given a set of optimization targets such as accuracy, latency and energy consumption, it can find an AI model structure that meets all requirements. The NAS algorithm does so by applying changes to the model structure and determining if the resulting model is better or not. By repeatedly applying good changes to the model, the quality improves and the optimization targets can be met. When AI is used to decide which changes are good, the result is an intelligent design tool. This AI driven AI design is fully automatic and can outperform human experts in both development time and the quality of the results.

Neural Architecture Search with Hardware in the Loop

At Fraunhofer ITWM, we work on intelligent NAS algorithms that can directly optimize AI models for any hardware platform. By treating the hardware as a black box, our NAS AI algorithms can infer from hardware measurements what the best design choices are. The NAS AI learns from the hardware feedback and improves its decision making. Since often there is no one best solution, our tool investigates several model design veins at once.

All of this is automatic, yet transparent to the AI engineer, since all design decisions are traced and can be reviewed. This helps to understand why our NAS AI reached the designs it is suggesting. The AI engineer stays fully in control of the search, yet it boosts their productivity.

For more information:

Contact

Dominik Loroch
Fraunhofer ITWM
dominik.loroch@itwm.fraunhofer.de

Neuromorphic Computing: When Technology Understands our Heart

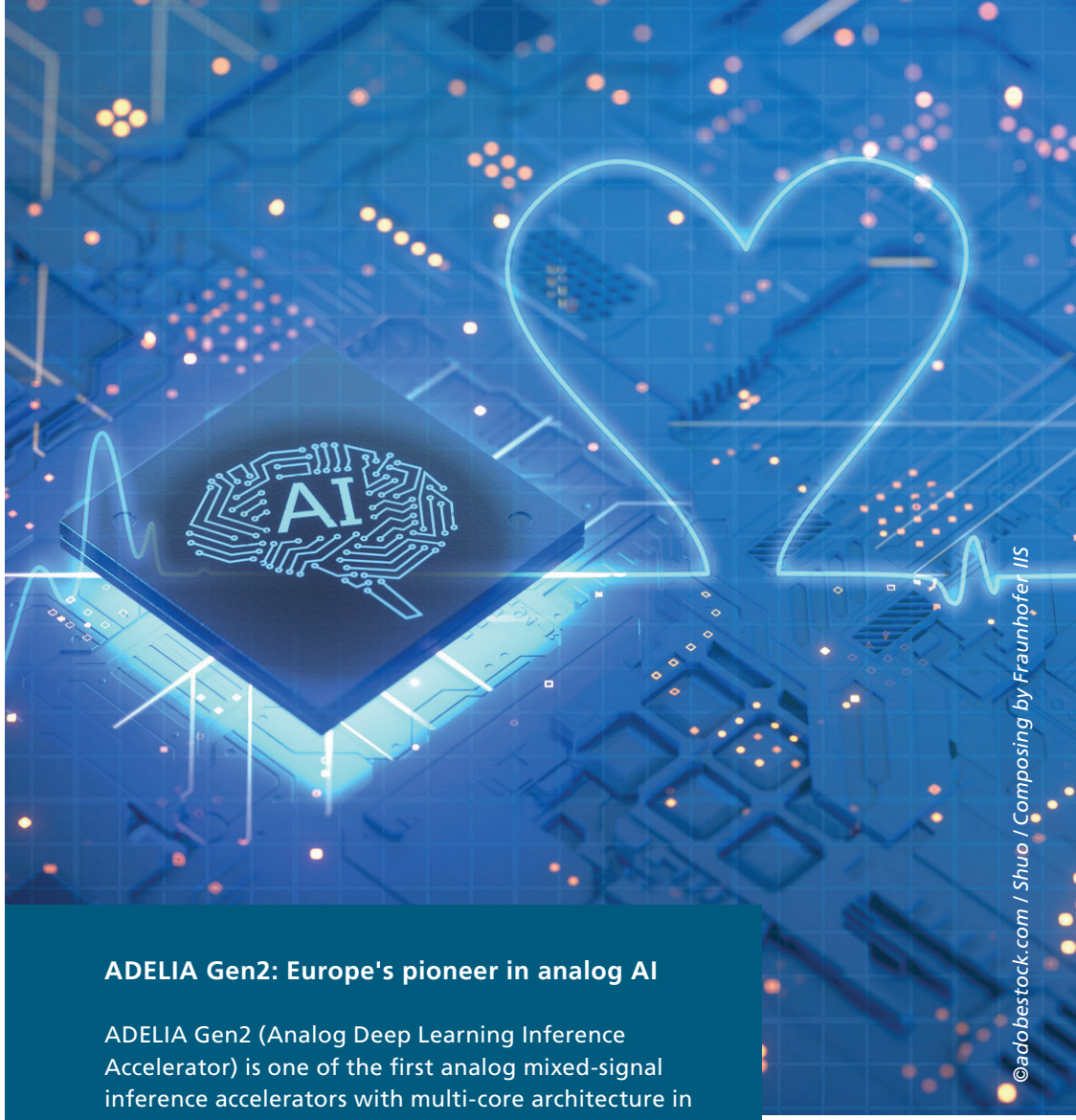
The combination of artificial intelligence and innovative hardware promises solutions that go far beyond conventional approaches. One exciting example of this is the use of neuromorphic computing for the energy-efficient analysis of electrocardiogram (ECG) data, which can provide valuable information about the general health of the heart in real time. This technology can be integrated into tight-fitting functional clothing or chest straps already established for pulse monitoring in sports to bring fitness and physical as well as mental health monitoring to the next level.

The heart is the motor of our lives – an organ that works in time with the sinus node, which emits electrical impulses and controls the contraction of the heart muscle. It is precisely this electrical activity that an ECG measures and that makes it possible to monitor the condition of the heart by electrodes. However, analyzing this data requires computing power that is limited, e.g. in wearable applications.

This is where neuromorphic computing comes into play: Inspired by the human brain, an artificial neural network running on highly efficient accelerators is trained to recognize various heart conditions. With the help of this specially developed neural network, the technology recognizes heart problems such as atrial fibrillation or other arrhythmias with unprecedented efficiency – even in real time.

Difference to conventional solutions

The technology is based on an electrical ECG sensor that requires direct skin contact and can be integrated into chest straps or textile wearables, for example.
This approach differs fundamentally from smartwatches, which measure the pulse optically and are usually based on long-term analyses to calculate a general risk of atrial fibrillation. The neuromorphic system, on the other hand, works with pinpoint accuracy and in real time: even during physical exertion, such as during sports, it can detect atrial fibrillation with high accuracy so that those affected can be informed immediately of potential cardiac arrhythmia to act in adequate time. In telemedicine, patients in rural areas could transmit their health data directly to medical professionals, leading to rapid diagnosis and treatment.



Neuromorphic computing as the interface between technology, data, and human health.

ADELIA Gen2: Europe's pioneer in analog AI

ADELIA Gen2 (Analog Deep Learning Inference Accelerator) is one of the first analog mixed-signal inference accelerators with multi-core architecture in Europe. The ASIC was developed by Fraunhofer EMFT and Fraunhofer IIS as part of the ECSEL JU project ANDANTE, which incorporates a total of ten partners and has a funding volume of 40.58 million euros.

ADELIA: Analog meets digital for improved AI performance

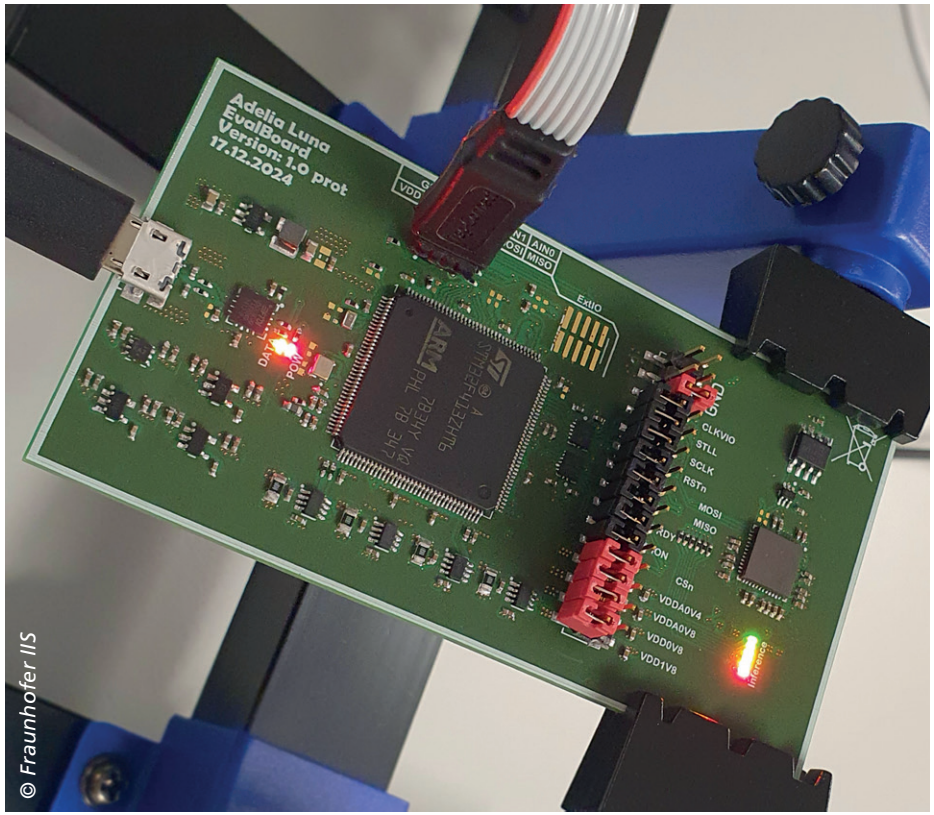
The core of the solution is ADELIA, the »Analog Deep Learning Inference Accelerator«. This scalable analog AI accelerator enables the extremely energy-efficient calculation of deep neural networks. Data processing takes place directly on the chip – an approach that not only saves energy, but also increases data security, as sensitive raw data does not even have to leave the sensor node. The use of analog computing improves performance by a factor of 10 compared to purely digital accelerators. The first applications already show the potential of ADELIA. In voice activity recognition, the chip with a power consumption of less than 200 µW achieved an accuracy that is in no way inferior to that of a fully digital solution – but with a fraction of the energy consumption. The researchers have already won an award for the evaluation of ECG signals using a digital AI accelerator in medicine.

Flexible eval kit for the practical test

An evaluation kit is available for the proof of concept, which can be used to demonstrate the performance of the technology, using Fraunhofer's sensor interface technology maphera®. It enables, for example, a free selection from many available ECG sensors, which can be connected to the microcontroller unit via Bluetooth. Here, the AI model takes over the analysis of the digitized sensor data and recognizes heart rhythms with impressive latency and power consumption. Additional neural networks can be seamlessly executed on the accelerator using an existing software ecosystem.

Pioneering for diagnostics and everyday life

ADELIA redefines precision, speed and energy efficiency. The intelligent combination of neuromorphic computing and modern sensor technology has the potential to fundamentally transform the healthcare market. Life-saving diagnoses could become directly available in everyday life – exactly where they are most urgently needed.



© Fraunhofer IIS

ADELIA evaluation kit

For more information:

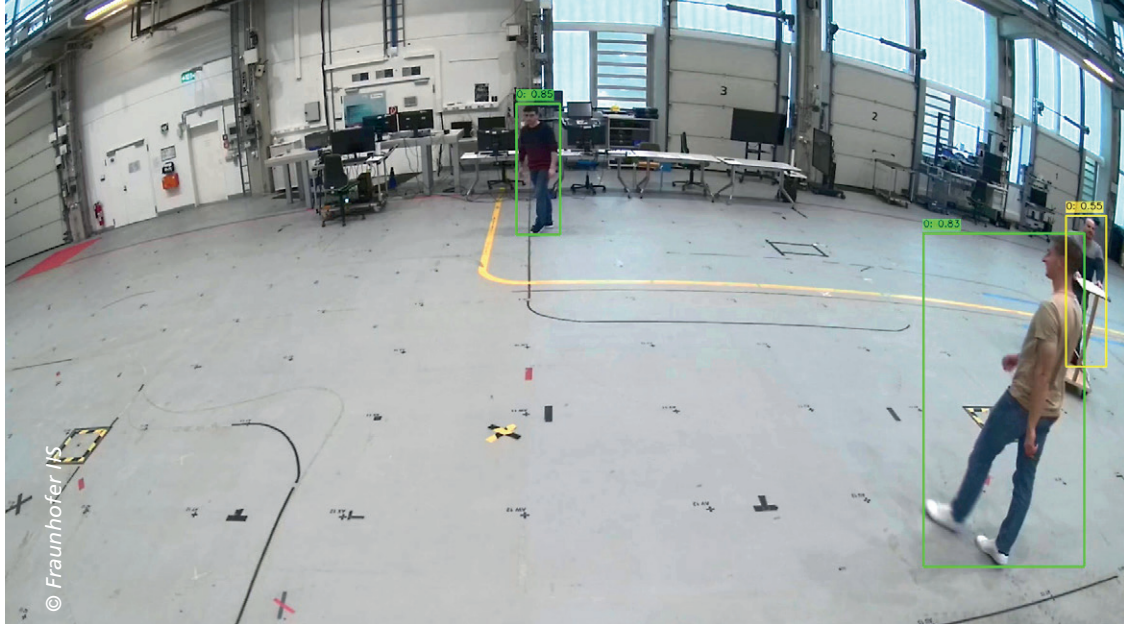
Contact

Dr.-Ing. Markus Eppel
Fraunhofer IIS
neuromorphic@iis.fraunhofer.de

Always in the Right Place with AI
Edge AI

Safe, fast and resource-efficient

Artificial intelligence (AI) can create significant added value in the right place for many industrial applications. Especially where data sovereignty or energy efficiency are of concern, Edge AI shows its strengths.
The experts at Fraunhofer IIS are working on concepts and solutions that use AI directly on existing embedded hardware equipment. They work on classification, tracking and anomaly detection tasks in the fields of machine vision and sensor data, where fast response times and high resource efficiency count.



Using AI in existing embedded systems

Our approach considers two main factors that make it easy for many small and medium-sized companies to harness the benefits of AI and machine learning methods: We support our project partners in selecting suitable models, develop the necessary algorithms accordingly or adapt them depending on the specific use case. We also employ AI tools that enable super-fast training and adaptation to the companies' data with minimal manual effort. With Edge AI models, analyses can be directly carried out in the embedded system. A connection to a cloud system is not necessary; it can also work without an internet or mobile connection. The analysis data remains sovereign within the company or the corresponding embedded system.

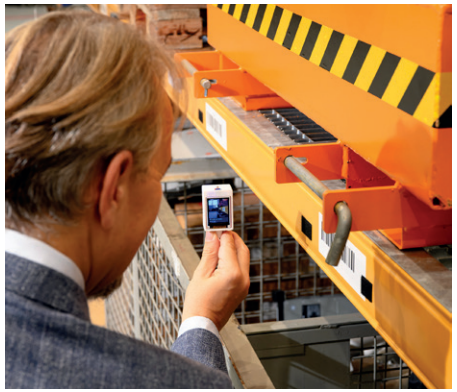
Edge AI offers low latency and sustainability

The local and direct data processing "on the edge" offers direct benefits: It is fast with minimal latency as the data are processed directly in the device without network transfers. It is super energy efficient as the algorithms run on microcontrollers rather than PCs or cloud servers. Overall, the Edge AI solutions are highly energy efficient and thereby sustainable. Typically, there is no increase in costs for higher energy requirements or for new hardware or components. Existing devices can continue to be used and can only be replaced with new ones or expanded with additional devices if necessary. On top of that, we offer on-device training and easy access to further simplify the use and minimize effort and energy requirements.

DIY and BYO – but with "Know How"!

We also enable companies to adapt the AI/ML for their industrial processes themselves and thus transfer the relevant technological expertise to the company. We also offer certified training courses for this purpose.

Our Edge AI offering is therefore directly aligned with the requirements of companies. It allows a low-threshold, quick and easy entry into these new technologies and offers accompanied know-how development for the design of a company's own transformation.



Edge AI for Machine Vision

For more information:

Contact

Dr. Axel Plinge
Fraunhofer IIS
machine-learning-lv@iis.fraunhofer.de

Edge-AI: Transforming Ideas into Action

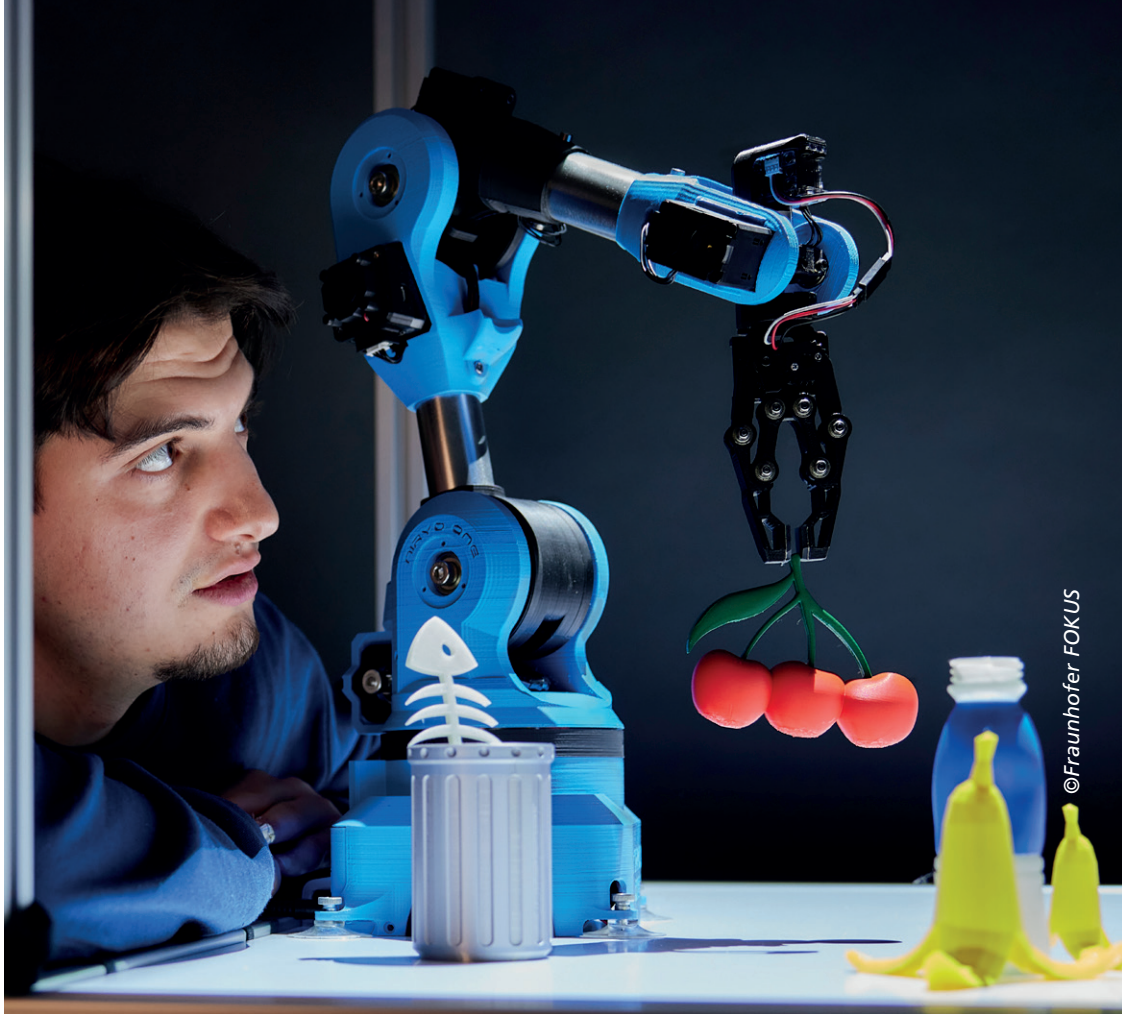
Real-time solutions without network dependency

In an evolving tech world, Edge-AI emerges as a key innovator, offering secure and efficient solutions across diverse domains. By enabling real-time object detection and decision-making, it enhances operations in industries such as robotics and logistics. Its applications span healthcare, smart homes, and more. Gesture detection and augmented reality further simplify interactions, improving safety and productivity. Fraunhofer FOKUS supports businesses in implementing Edge-AI, ensuring robust data security and operational efficiency while enabling cost-effective scalability.

In today's rapidly evolving technological landscape, Edge-AI is a beacon of innovation for a broad range of markets. By infusing existing systems with edge intelligence, it delivers a secure, scalable, and efficient solution suitable for numerous applications. The integration of real-time object detection, augmented reality, human-machine interaction, and AI processing at the edge enhances operational efficiency and data security.
This decentralized approach showcases its potential across various domains where speed, security, and adaptability are crucial.

Versatile Object Detection with Edge-AI

Edge intelligence's core advantage lies in its AI operating directly on the edge device, facilitating applications like real-time object detection. Unlike traditional cloud systems that introduce latency, Edge-AI executes local data processing, ensuring immediate decision-making. This real-time capability is vital in high-speed domains like robotics and logistics, preventing inefficiencies caused by delays. The embedded AI model precisely analyzes camera feeds to detect and locate items, enabling autonomous functions such as inventory management, quality control, and sorting.



Sectors ranging from smart cities to autonomous vehicles benefit significantly from the swift responsiveness provided by Edge-AI, ensuring functionality even in areas with unstable network connections. Additionally, object detection can enhance wildlife monitoring, healthcare diagnostics, and agricultural efficiency.

Different algorithms, some of which can be trained on the edge, support these diverse applications. The capacity to process complex tasks in constrained environments where energy constraints exist is another advantage of this remarkable technology.

Enabling Real-Time Control Across Domains

Edge-AI revolutionizes how sensor data is processed and used to control various actuators, including robotic arms for tasks like object placement. The local data processing ensures real-time responsiveness to environmental changes, crucial in industries like manufacturing and logistics. Independence from constant cloud connectivity reduces downtime risks linked to connectivity issues, ensuring reliable operations. Edge-AI's potential extends beyond robotics, such as improving smart home systems, optimizing drone logistics, and enhancing smart city infrastructure, showcasing its versatility across multiple domains. It transforms small devices into powerful tools in places where conventional connectivity might be a hindrance.

Beyond Touch: Simplifying Interactions with Gesture Detection

Gesture detection enhances human-machine interaction by translating hand movements into commands for devices like robotic arms, offering an intuitive interface. This simplifies human-machine interaction by reducing the need for manual inputs. In industrial settings, it can be used to control machinery or navigate complex interfaces without physical contact, improving safety and efficiency. In healthcare, gesture detection provides a touch-free way to navigate through medical visualization interfaces, enhancing hygiene and efficiency. This user-friendly approach simplifies interactions across diverse fields, surpassing traditional input methods. With further advancements, this technology promises to augment accessibility tools, enabling more inclusive use of digital interfaces. From education to entertainment, the scope of gesture-based technologies is expanding considerably.

AR and Edge-AI: Transforming Operator Efficiency

Augmented reality (AR) enhances human-machine interaction by providing real-time visual feedback to operators. Through AR, operators can view data overlays, step-by-step instructions, and diagnostics directly in their field of vision. This improves efficiency during training, troubleshooting, and daily operations. The combination of Edge-AI and AR enables intuitive decision-making, allowing operators to visualize tasks in a spatial context. As a result, operators can interact more effectively with robotic systems, optimizing workflows and increasing productivity. Companies stand to benefit by reducing errors and lowering labor costs as operators become more adept at handling complex machinery with AR guidance.

Efficiency and Security: The Edge-AI Advantage

The advantages of Edge-AI include heightened data security and privacy through local processing, eliminating the vulnerabilities of cloud-based data exchange. Its adaptable architecture scales across diverse applications, from real-time inventory management to automated systems, catering to both small and large-scale operations. This scalability, coupled with real-time decision-making, ensures increased efficiency and cost savings.
Fraunhofer FOKUS, with its extensive research experience in Edge-AI, provides support for implementation, research, and consulting to companies seeking to integrate Edge-AI solutions. These innovative implementations ensure that businesses remain competitive and harness the full potential of technology.

For more information:

Contact

Marko Harasic
Fraunhofer FOKUS
marko.harasic@fokus.fraunhofer.de

Mobile Ad Hoc Networks as the Key to Resilience

Reliable, cooperative, dynamic – this is how Felix Kreyß, Group Manager Embedded Systems at Fraunhofer IIS, characterizes self-organizing mobile ad hoc networks. In this interview, he explains why this special type of mesh network is gaining increasingly relevant in industrial environments and what potential it holds for the future.

Felix Kreyß

What are mobile ad hoc networks and how do they work?

Mobile ad hoc networks allow participants, such as cell phones, sensors or drones, to move around while reliably exchanging data. The networks are self-organizing, meaning they do not require a central control unit and can autonomously establish connections at any time. This not only makes the networks much more flexible, but also increases their reliability in dynamic environments. At the same time, they are independent of conventional communication infrastructure, such as mobile radio, which makes them well-suited for use in remote or underserved areas.

What are the advantages of mobile ad hoc networks over traditional architectures?

The biggest advantage is cost savings, as there is no need for expensive infrastructure. In contrast to conventional networks that rely on centralized control units, the costs of ad hoc networks scale only with the number of participants. With our Fraunhofer technology "RANDLE", we can use commercially available, cost-effective, so-called commercial off-the-shelf hardware in these networks without having to compromise on quality.

"RANDLE" acts as a decentralized mesh orchestrator, enabling reliable routing and network management, thus facilitating wireless data exchange between mobile IoT devices. This allows us to combine the best of both worlds: commercial affordability and high performance.

© Fraunhofer IIS / Paul Pulkert

Swarms of drones that can communicate via mobile ad hoc networks are revolutionizing the inspection of remote or underserved areas

Another advantage of mobile ad hoc networks is their ability to reorganize themselves. If a participant goes down, the network automatically finds alternative transmission paths.
This resilience is especially valuable in dynamic environments. Furthermore, the independence from central infrastructure and the cost-effective implementation with off-the-shelf hardware enables rapid deployment and adaptation. This makes the networks ideal for embedded systems.

Where do you see the greatest potential for these networks?

Basically, these mobile ad hoc networks are well suited to environments where uninterrupted communication is not a given. However, we see the greatest potential in the field of mobile robotics, especially for logistics robots and drones.

We are currently particularly interested in swarms of drones that can be used to efficiently inspect hard-to-reach areas, such as offshore wind turbines. Mobile ad hoc networks enable coordinated communication between these drones, which significantly reduces inspection times.

For more information:

Contact

Felix Kreyß
Fraunhofer IIS
felix.kreyss@iis.fraunhofer.de

Virtual Test Benches to Validate Off-Road Applications

Testing highly automated and autonomous agricultural vehicles is costly and labor-intensive. Configurations and scenarios must be verified to evaluate and release new technical systems for agriculture. Real test drives on this scale are impractical, making virtual test benches essential. FERAL leverages digital twins and simulations, applying continuous engineering principles to enable cost-efficient validation and optimization for seamless integration.

Retrofitting of existing farm equipment

Upgrading and integrating existing agricultural equipment with modern technology transforms agricultural off-road vehicles into smart farming devices. By incorporating various sensors such as LIDAR and RADAR, cameras, and communication devices this upgrade improves safety, precision, and operational efficiency. Thorough virtual validation of these upgraded systems ensures compatibility and reliable performance, supporting the integration of digitized and data-driven agricultural practices.

Deploy to realistic virtual test platforms

Testing is performed in a fully virtual environment, replacing costly HiL (Hardware in the Loop) testing with virtual validation scenarios by integrating simulation models and tools. Our FERAL toolbox combines multiple components, including E/E platforms, networks, driver and operator models, and cameras. This approach allows your test team to validate digital farming features remotely, eliminating the need for expensive and resource-intensive HiL testbeds and field tests.

© istock.com / Niclasbo / Fraunhofer IESE

Early validation of safety-related features at design time

Automated safety systems – like collision detection for people and animals – ensure reliable operation in challenging conditions, such as dust or poor visibility. FERAL ensures continuous monitoring and assessment of operational processes with digital twins at the design level.
This addresses dynamic hazards in autonomous operations and enhances safety compliance with standards like ISO 25119 and ISO 18497 (Safety of highly automated agricultural machines).

Enabling CI/CD for smart farming equipment

Integrate virtual test benches into your development and testing workflows for seamless, continuous engineering of digital farming features. FERAL's versatile interface integrates virtual test benches into your CI/CD tool pipeline, accelerating development processes and reducing time to market.

For more information:

Contact

Dr. Pablo Oliveira Antonino
Fraunhofer IESE
pablo.antonino@iese.fraunhofer.de

mioty®: IoT Allrounder for Hardware and Applications

The Internet of Things (IoT) has long been part of our everyday lives. Countless devices and sensors in our environment – connected via IoT – collect, analyze and interpret our data. In recent years, cities have been increasingly relying on low powerwide area networks (LPWAN). However, they still face many challenges, such as missing scalability. If the technology used is not sufficiently scalable, high costs for additional base stations and repeaters quickly arise. One of the solutions to this problem is the mioty® protocol. René Dünkler tells us more about the technology in an interview.

René Dünkler

What is mioty® in detail?

René Dünkler: mioty® is an IoT protocol that enables the data transmission of large amounts of sensors over long distances. The core of this technology is the unique transmission method called 'telegram splitting'. The data package is divided into small sub-packages which are then sent with a time delay. The receiver needs less than 50% of the sub-packages to be able to decode the original data package. This ensures a reliable and stable connection, even under difficult conditions.

What distinguishes mioty® from conventional LPWAN solutions?

René Dünkler: Thanks to the telegram splitting method, mioty® is cost and energy efficient as well as very robust and reliable. One base station ensures a network capacity of 3.5 million messages a day. We also offer the base station as an energy self-sufficient solution for areas without a power connection, such as agricultural fields. Furthermore, mioty® is a software-based solution. It operates on all Sub-GHz radio transceivers and can be used regardless of manufacturer, for example Texas Instruments, Silicon Labs, STMicroelectronics, making it easy to adapt to local regulations. We will actually present chipsets from these companies at the embedded world 2025.

Energy self-sufficient mioty® base station for agricultural applications

mioty® seems to be very versatile. In which fields of application can it be used?

René Dünkler: mioty® is very adaptable. It can be applied to a wide range of applications such as smart cities, smart metering and industrial IoT (IIoT). Our latest projects have included collaborations with various farms. One project focused on monitoring the temperature of the dams. By using mioty®, maintenance costs were reduced and an optimal irrigation strategy was developed. In another project, the focus was on measuring the concentrations of nitrate and ammonium ions in suspended soil samples. The measurements allow the use of fertilizer to be reduced to the exact amount required, thereby reducing nitrate pollution. This is not only an important contribution to the protection of biodiversity, but also saves farmers time and money.

Will you be showcasing agricultural applications at the embedded world?

René Dünkler: Yes. We will demonstrate how mioty® can be used by farmers to optimize the use of water, soil and fertilizer resources. We will also display our energy self-sufficient base station and sensors that transmit data with mioty®.

How do you ensure that mioty® is reliably used in various applications?

René Dünkler: We founded the mioty alliance, a partner network of technology providers, system integrators and end users. With currently around 60 members, the mioty alliance represents the entire IoT value chain and will be present at the embedded world. Also, we are going to host a networking event at our booth.

For more information:

Contact

René Dünkler
Fraunhofer IIS
crm-mioty@iis.fraunhofer.de

Bavarian Chip-Design-Center: More Innovation Through Chip Design

The Bavarian Chip-Design-Center (BCDC) strengthens chip design capabilities in Bavaria and makes it easier for companies to access chip design and supply chains. Dr.-Ing. Thorsten Edelhäußer, head of the BCDC, takes a look at the role of the BCDC, current developments and future prospects.

How does the BCDC promote innovation in chip design?

The BCDC promotes innovation through research in thematic platforms that produce solutions in the areas of Sensor & Actuator Systems and AI, Digital Signal Processing, Secure System-on-Chip, Chip Solutions and Chiplet Systems. A particular focus is on the development of a comprehensive IP portfolio, supported by the Fraunhofer Institutes AISEC, EMFT and IIS as well as Bavarian universities. This cooperation strengthens Bavaria as a location for innovation in the long term.

How does your center support companies?

Companies benefit from us at every stage of chip development because we enable accessible and efficient chip development – from feasibility studies to error analysis. We achieve this by shortening development times and reducing development costs.

We develop specifications and IP blocks, design ASICs and systems and rely on the reuse of proven components.
We also support companies as a partner in small-volume production and provide access to the latest semiconductor technologies through a support interface to semiconductor manufacturers, which includes layout reviews, the tape-out process, multi-project wafer runs and the provision of full-mask sets (engineering run). This also includes test and packaging as well as supply chain management.

How are you addressing the skills shortage in the semiconductor ecosystem?

Our trainee programs and certified further training are a central approach. The first trainees will start on the BCDC IC-Design Talents program in 2025. They will initially work in the areas of Analog IC Design, Test & Validation and System Engineering.
We are also planning to expand capacities and content. We have also held discussions

The BCDC is organised in three pillars and pursues four objectives.

with companies that have expressed a clear need to train employees via our trainee program. We want to create an offer that not only promotes young talent, but also experienced specialists.

The BCDC has already achieved its first successes. Can you tell us more about this?

We were able to present the first tape-outs and validate circuit IPs on silicon, e. g. for neuromorphic hardware. The close exchange with industry ensures that our developments meet the actual needs of companies. In Bavaria in particular, we have close contacts with companies in order to drive joint projects forward.

Does the BCDC also network nationally and internationally?

Yes, the BCDC operates nationally and internationally and is recognized as a major player. This is demonstrated, for example, by invitations to be a panelist at the Bavarian Semiconductor Congress or for a presentation at the European Semiconductor Regions Alliance (ESRA). We are also part of initiatives such as "Chip-Design Germany" and maintain international contacts, e. g. to Taiwan and Mexico.

Finally, what makes the BCDC so special in the semiconductor ecosystem?

We see ourselves as a central point of contact in the semiconductor ecosystem. By expanding our research capabilities and building a strong network with the industry, we are driving forward strategic initiatives – both at national and EU level.
Supported by the Bavarian State Ministry of Economic Affairs, Regional Development and Energy, we are continuously expanding our expertise. Our combination of specialized know-how and strategic partnerships will not only have a lasting impact on the technology market, but will also enable decisive innovations.

Dr.-Ing. Thorsten Edelhäußer

For more information:

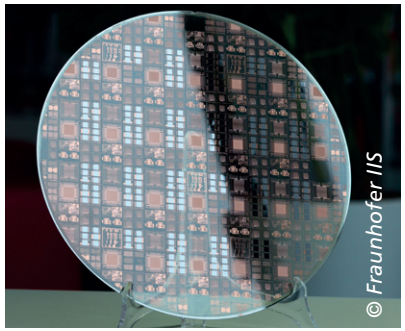
Contact

Dr.-Ing. Thorsten Edelhäußer
Fraunhofer IIS
bcdc@iis.fraunhofer.de

Specific and Extremely Robust Chiplet Solutions for Automotive and Industrial Applications

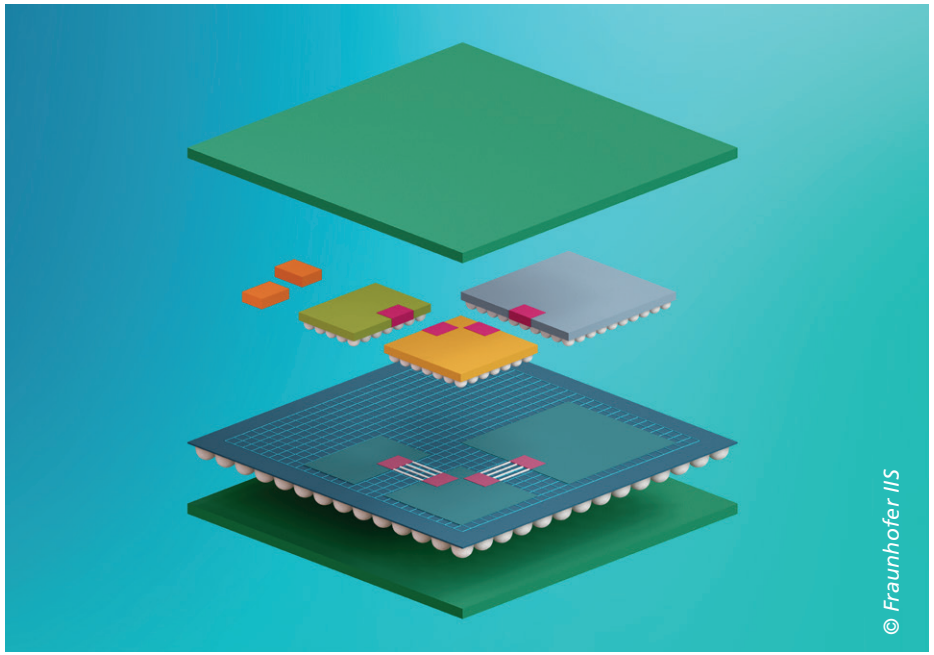
Chiplets offer considerable advantages for the automotive and industrial sectors by enabling cost-effective production of high performance chips through their modular design. However, deploying chiplets in these environments entails challenges such as the need for robustness against extreme conditions and the complexity introduced by the diversity of semiconductor technologies. Experts at Fraunhofer IIS/EAS are positioned to address these challenges and support the implementation of chiplet technology.

Chiplets hold significant potential for the automotive and industrial sectors, where high performance is essential, but production volumes are often low. Their modular design allows for efficient production, enabling individual components to be created once and combined flexibly for tailored solutions, leading to cost-effective high-performance chip production.



Challenges posed by the harsh conditions of automotive and industrial applications

However, using chiplets in these demanding environments presents unique challenges. Automotive and industrial systems must be robust enough to withstand extreme conditions, including thermal cycling and mechanical stresses. Additionally, the heterogeneity of semiconductor technologies required for chiplets adds complexity. Many applications necessitate specialized materials like gallium nitride (GaN) or silicon carbide (SiC), which have higher threshold voltages and lower transistor densities than standard CMOS technologies.



Chiplet system

Specialized solutions and comprehensive testing are required to ensure that chiplet systems can withstand extreme conditions

Thus, specialized solutions are needed to ensure long-term stability and reliability. This requires reevaluation of existing designs as well as significant advancements in standards, testing methods, and design processes.
The chiplet experts at Fraunhofer IIS/EAS address these challenges and are your partner in the implementation of this promising technology.

For more information:

Contact

Andy Heinig
Fraunhofer IIS
Division Engineering of
Adaptive Systems EAS
andy.heinig@eas.iis.fraunhofer.de

Radar Platform for Spatial Motion Detection and Positioning

What do automatic doors and self-driving vehicles have in common? They share a need for the precise localization and motion detection of the people and objects around them. Specialized radar systems can offer highly reliable and robust solutions, but the hardware and software can be time-consuming and cost-intensive to develop. Fraunhofer IZM now offers a universal radar platform to facilitate the development of applications for positioning and motion detection.

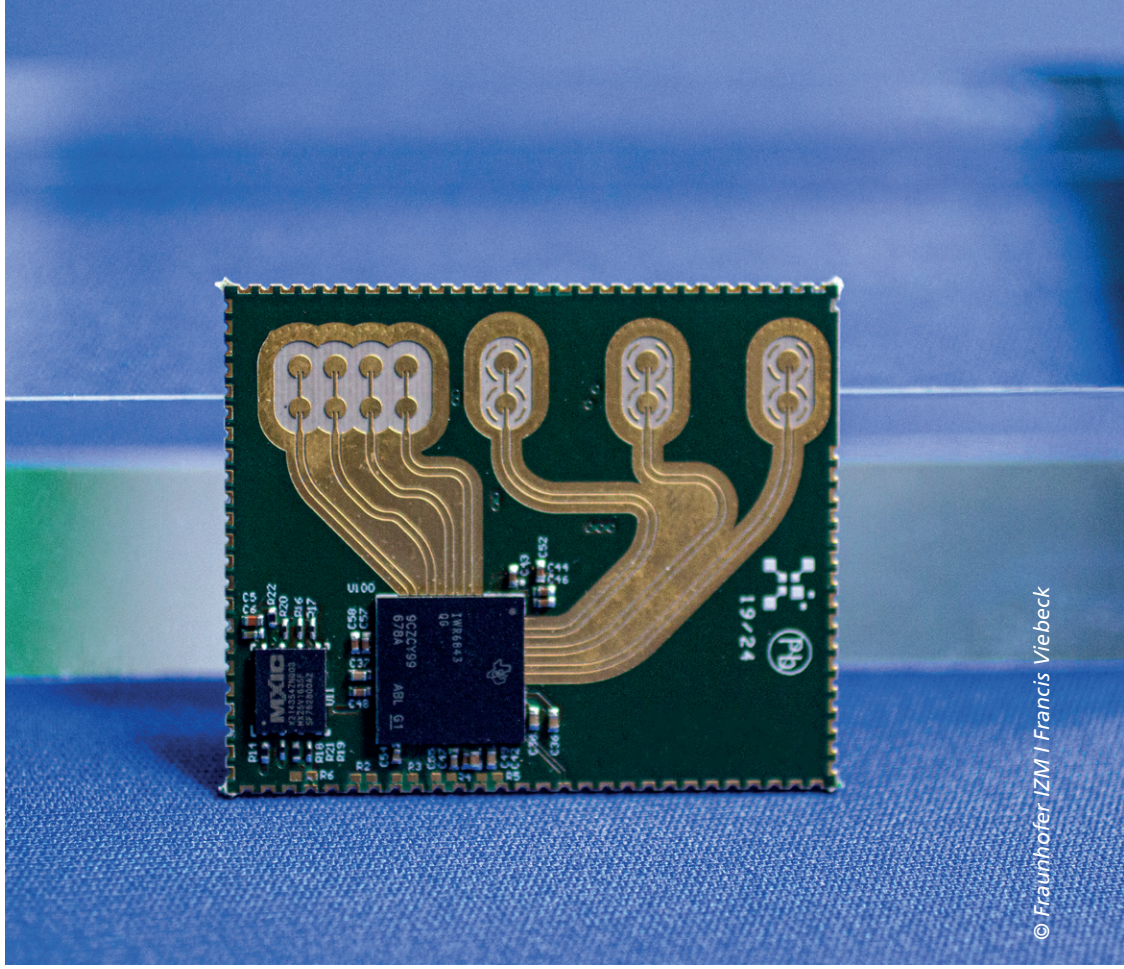
The radar experts at Fraunhofer IZM have developed a compact MIMO radar system to track and localize people and objects in space. At embedded world 2025, the functionality of this system will be on show in the form of a miniaturize Ferris wheel equipped with two separate radar modules.

One module uses a linear antenna array for angle measurements in one plane, while the second uses a rectangular array that can detect the movement of the gondolas in both vertical and horizontal directions.

A MIMO radar kit for rapid prototyping

The 60 GHz radar system is part of a radar construction kit that was developed in collaboration with the Technical University of Berlin. This radar construction kit makes it possible to design and test applications faster and more efficiently for position and motion detection in private and industrial environments. This can be put to work in the automatic doors, access controls, or as support for autonomous air and water vehicles when landing or determining their position.

Based on the construction kit's output, the necessary hardware can be specified and implemented, removing the need for iterative loops when developing hardware and software in parallel. The hardware can be developed specifically for each application in a single pass.



Radar sensor

Prototypes for radar sensors with frequencies of 60 and 79 GHz can be created faster with the cost-effective radar construction kit. These sensors cover ranges from 0.1 to 260 meters and angular resolutions of less than 10°. The different frequencies can be combined with single and MIMO antenna concepts.

For more information:

Contact

Dr. Christian Tschoban
Fraunhofer IZM
christian.tschoban@izm.fraunhofer.de

Autonomous and Energy-Efficient Sensor-Actuator Platform

Smart manufacturing, smart logistics, or smart farming: Distributed sensor networks are working hard for us every single day. In the past, every application needed a custom solution to operate sensors and process data. Researchers at Fraunhofer IZM have created the autonomous and energy-efficient sensor-actuator platform SWARMY that can be easily mixed and matched for each purpose – saving lots of effort and resources in application development and commissioning.

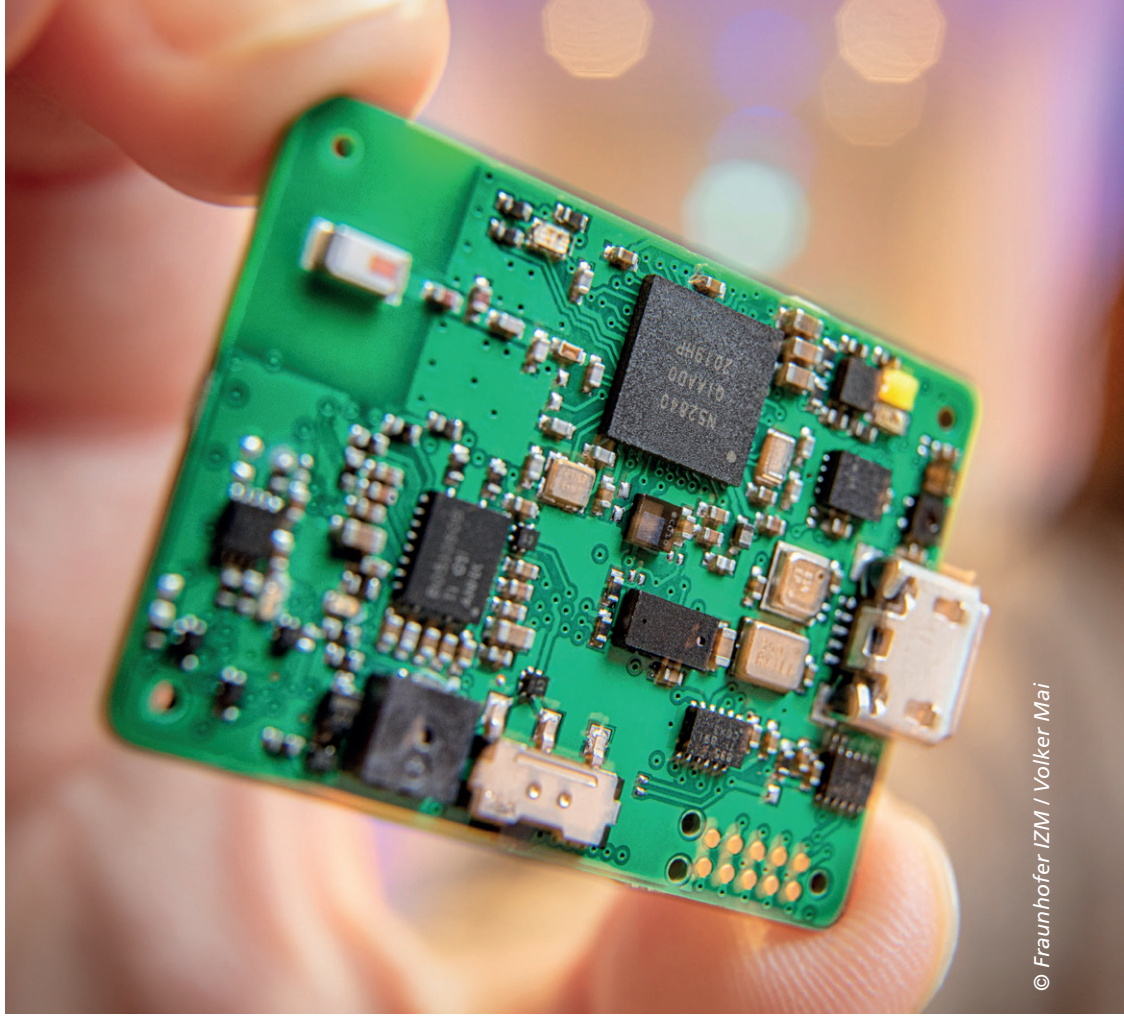
Wireless sensors are ideal for monitoring and analyzing processes on distributed and moving objects in manufacturing, logistics, or agriculture. Fraunhofer IZM has developed both the hardware and the software for an autonomous and energy-efficient sensor-actuator platform called SWARMY. With a board size of just 36 mm x 26 mm, the sensor node can even be mounted in places that are otherwise difficult to access.

The SWARMY platform has a modular design and comes with up to 8 different integrated sensors for purposes like measuring vibrations or tracking the temperature of systems and components. The integrated sensors can measure the following parameters: Acceleration, angular acceleration, light, humidity, pressure, and distance, with customizable measuring intervals and degrees of sensitivity.

If required, interfaces are available to connect the system to external sensors, like the frequently required strain gauges. Customer-specific configurations are also possible.

Hardware and firmware are designed to be energy-efficient to ensure long operating times. A robust wireless connection is ensured with minimal-power transmissions required, as the data is transmitted via Bluetooth Low Energy. Alternatively, protocols such as LoRaWAN are also possible.

SWARMY is ready for immediate use and only requires 2 to 3 hours of training to be used efficiently even without previous experience.



© Fraunhofer IZM / Volker Mai

Modular multi-sensor platform: Configurable sensor technology for various measurement scenarios with local data processing and a wireless communication interface.

For more information:

Contact

Carsten Brockmann
Fraunhofer IZM
carsten.brockmann@izm.fraunhofer.de

A Toolbox for Neuromorphic Edge Computing Systems

Inspired by biological brains, Neuromorphic Computing promises to achieve improvements in energy efficiency and latency of computing hardware beyond Moore's law. Making neuromorphic computing reality requires adaptations on all abstraction levels of computing, from novel in-memory computing devices to Spiking Neural Network (SNN) algorithms. In the internal project "SEC-Learn: Sensor Edge Cloud for Federated Learning" a consortium of 11 Fraunhofer institutes developed a comprehensive toolbox for future neuromorphic edge computing systems.

Neuromorphic Computing is the multi-disciplinary effort to build sensors, processors and algorithms based on principles observed in neurobiology. Neuromorphic systems are typically built around a neuromorphic processor, which accelerates the computation of Spiking Neural Networks (SNNs). SNNs are a network of concurrent, massive-parallel processes (neurons), which communicate binary pulses (spikes) via weighted connections (synapses) in continuous time. Compared to conventional artificial neural networks, SNNs can not only encode information in the value, but also in the timing of synaptic connections. This allows neuromorphic processors to perform calculations directly on the time information of sensor data without the need for expensive sampling and conversion of time information in a frequency representation. Thereby low latency and low power solutions for challenging edge computing applications like object detection with event-cameras or radar sensors are enabled. Building an edge computing system around a neuromorphic processor requires a broad range of skills. In the internal project "SEC-Learn" a consortium of 11 Fraunhofer institutes developed a comprehensive toolbox for the future development of neuromorphic edge computing systems, comprising the following tools:

Federated Learning (FL)

Edge devices collect valuable data, which can be used to improve already deployed applications. Federated Learning combines local training on edge devices with global knowledge exchange via the cloud. Thereby potentially sensitive, collected data stays private. Fully-homomorphic-encryption (FHE) makes it even impossible to deduce any private information hidden in the parameters of neural network models, while computing with them is still possible.

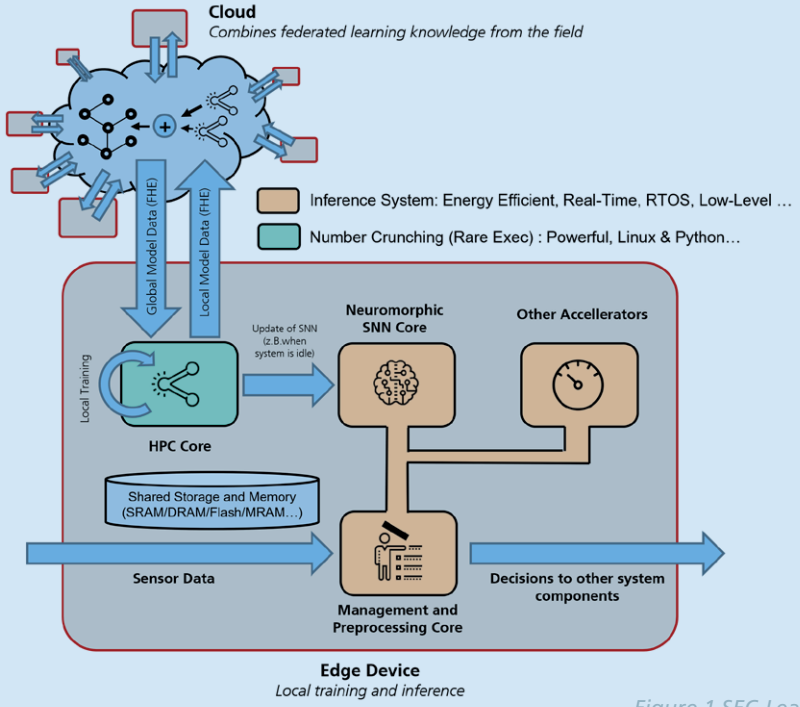


Figure 1 SEC-Learn edge computing platform demonstrator

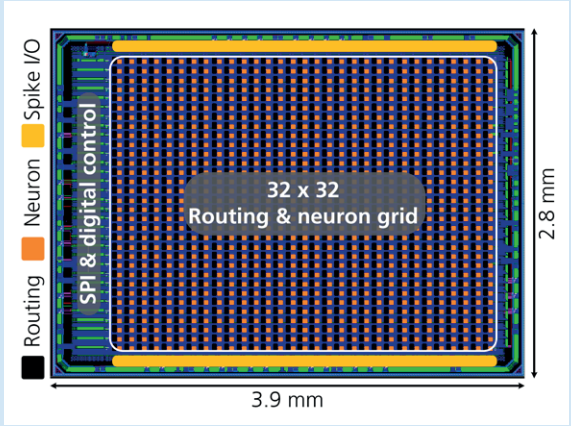


Figure 2 SENNA Prelude neuromorphic processor, comprising a Field-Programmable-Spiking-Neuron-Array (FPSNA) with 1024 mixed-signal neurons and digital asynchronous switchboxes, direct spike interfaces and on-chip spike generators and spike recorders.

Virtual Prototyping (VP)

Early verification with virtual prototypes in different abstraction levels saves total development time and can guide the co-design of data acquisition, data storage, data processing and actuators. Virtual prototypes are able to model both hardware and software of arbitrary, heterogeneous system components.

Neural Architecture Search (NAS)

The most critical parameter defining the latency and power consumption of a neural network running on any hardware is its size. Finding application specific, minimum sized neural networks with Neural Architecture Search (NAS) optimizes the system energy consumption and latency.

Spiking Neural Networks (SNNs)

Not every SNN is the same. As for conventional neural networks, there are a lot of options when it comes to network topologies and neuron models. The addition of time as an information carrier introduces additional complexity with respect to the encoding of input data into spikes and training of the temporal dynamics of SNNs. While back-propagation based training methods already work well for data samples with limited time precision and can for example detect objects with event-cameras, time-continuous training over longer periods is still a challenge.

Neuromorphic processors

The few available neuromorphic processors use serial interfaces based on the Address-Event-Representation (AER) format. This introduces time uncertainties due to (de-) serialization. The novel neuromorphic processor architecture SENNA and its proof-of-concept implementation SENNA Prelude provide direct spike interfaces and a completely time deterministic SNN inference, what enables real-time applications with unmatched, ultra-low latency.

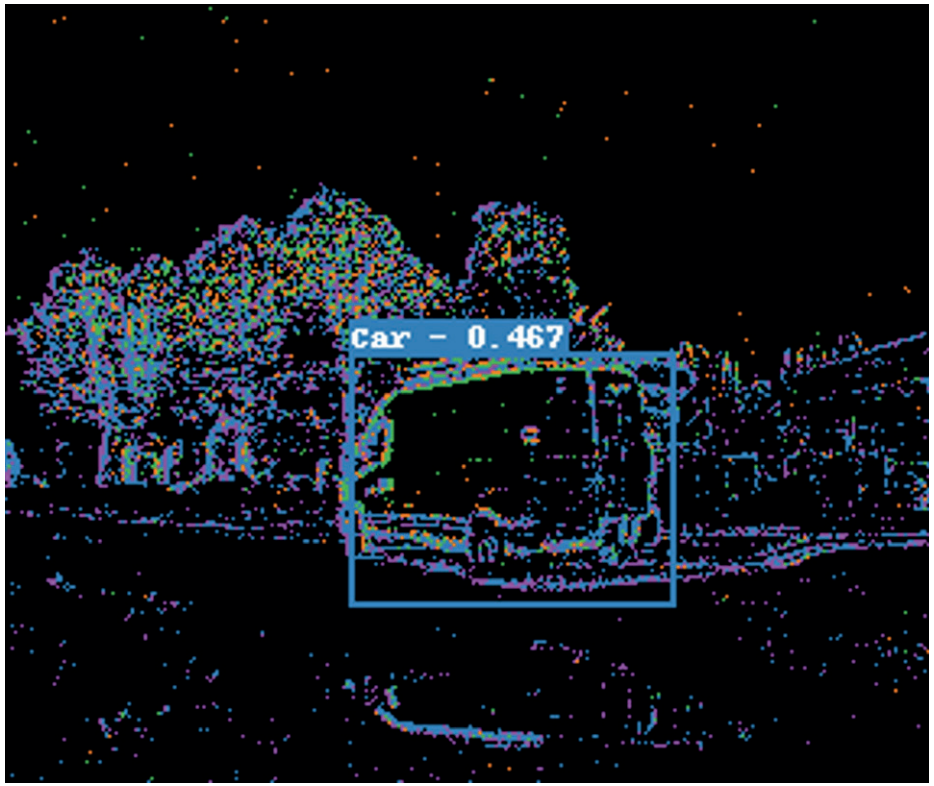


Figure 3 SNN object detection with Prophesee dataset from E. Perot et. al "Learning to Detect Objects with a 1 Megapixel Event Camera". To appear in 34th Conference on Neural Information Processing Systems (NeurIPS 2020).

For more information:

Contact

Ferdinand Pscheidl
Fraunhofer EMFT
ferdinand.pscheidl@emft.fraunhofer.de

What Does a Strawberry Have to do With Radio Technology?

A photo that arouses curiosity: a bright red strawberry with the measuring tips of oscilloscope probes plugged into it. At first glance, this photo may seem bizarre. But behind the curious scene lies a central question of modern electronics: how little energy does a radio receiver need?

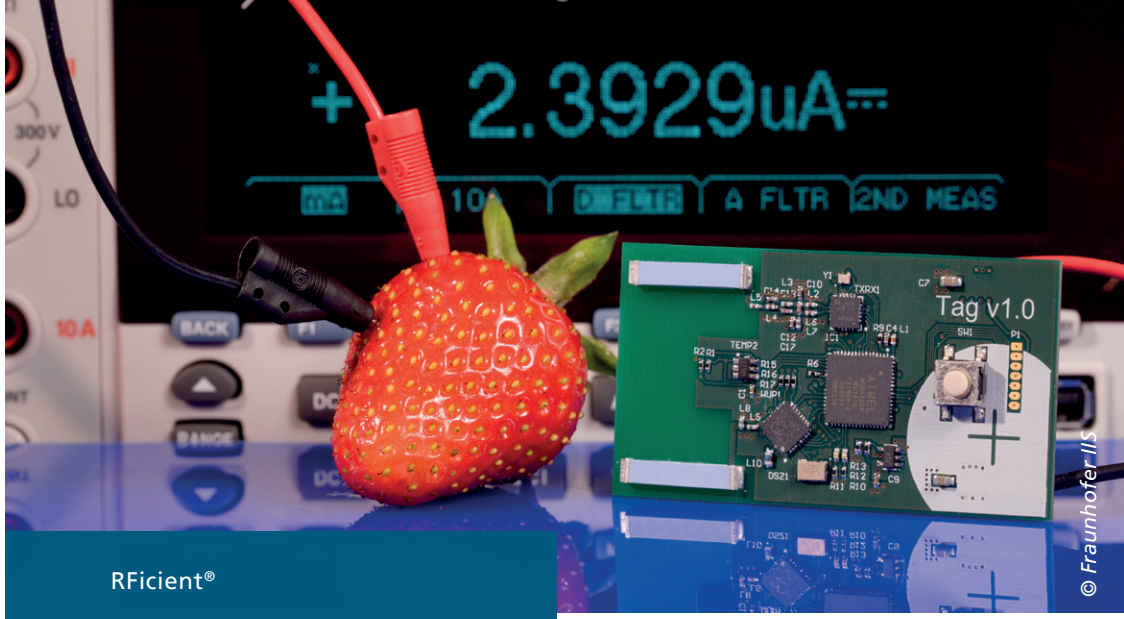
In a world increasingly characterized by wireless communication, energy efficiency is far more than a trend – it is a key to the future. Modern wireless systems can be particularly durable and low-maintenance if wake-up receivers are used. One technology that sets standards in this area is the RFicient® chip from Fraunhofer IIS. But what does a strawberry have to do with it?

RFicient® runs on almost no power – even from a strawberry

The RFicient® chip is an ultra-low-power wake-up receiver that enables wireless communication with minimal energy consumption. The chip requires only a few microwatts of power – a value so small that it can even be supplied by a strawberry. The »strawberry battery« makes use of the natural properties of a fruit. Two electrodes made of different metals are inserted into the berry, where the fruit acids trigger an electrochemical reaction as an electrolyte. This generates a low voltage – sufficient to operate an extremely energy-efficient chip such as the RFicient®. This experiment, which appears playful at first glance, is far more than just a technical gimmick: it impressively demonstrates how little energy is required to enable wireless communication.

Smart wake-up technology – fast on demand connectivity

The secret of the RFicient® chip lies in its architecture. It is an integrated radio receiver for short-range applications. It continuously monitors UHF channels and detects wake-up sequences within a very short response time of just 32 ms. This approach not only saves energy, but also opens up new possibilities: Sensors, wearables and other networked devices can be monitored with minimal battery capacity – ideal for applications where the focus is on longevity and sustainability.



Strawberry-powered? A tiny fruit enable wireless communication!

RFicient®

Origin: From RF (Radio Frequency), IC (Integrated Circuit) and efficient.

Meaning: A highly efficient radio receiver that impresses with its extremely low energy consumption.

Efficient wireless communication – ready to use today

The strawberry battery is therefore not only an eye-catcher, but also a symbol of the energy efficiency of RFicient® technology and proves that sustainable technologies are more than just a vision – they are already a reality. In a networked world where devices need to communicate with each other ever more efficiently, the RFicient® chip offers a forward-looking solution for long battery life with minimal energy consumption.

The technology is already available today: Developers can use samples, breakout boards and eval kits to test the RFicient® chip in their own projects.
This makes sustainable, energy-efficient communication a reality – a future in which even a strawberry could provide enough energy.

For more information:

Contact

Thomas Thönes
Fraunhofer IIS
rficient@iis.fraunhofer.de

Fraunhofer Joint Booth Hall 4-422

Adaptive Manufacturing with Embedded Edge-AI

Security Testing of Networked Products

Circuit Design for Neuromorphic Computing

Neural Archi-tecture Search for the Edge

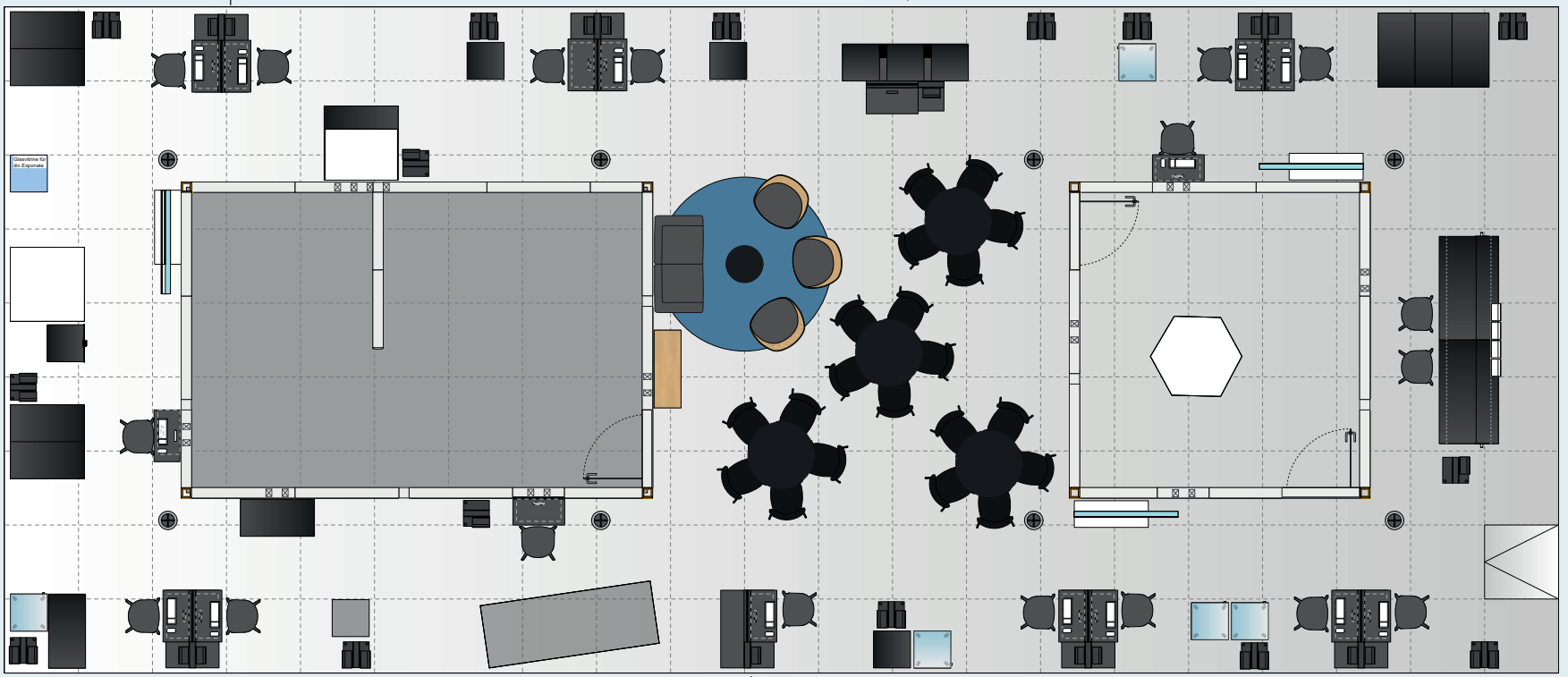
Edge AI Platform

Neuromorphic Computing for Edge AI

Mobile Ad Hoc Networks for Reliable Communication

MIMO radar kit for rapid prototyping

Autonomous energy-efficient sensor-actuator platform



Energy autarkic IoT Sensors

Future-proof LPWAN mioty®

Virtual Test Benches to Validate Off-Road Applications

From System Requirements to ASIC Design

Chiplet Integration

RFicient®

IC-Design

Bavarian Chip-Design-Center

The Fraunhofer Institutes demonstrate their latest developments, licensable solutions and technologies in the areas of edge AI, Green ICT, efficient sensor communication and sensor technologies and systems.

Fraunhofer EMFT
Institute for Electronic Microsystems and Solid State Technologies, Munich

Fraunhofer IESE
Institute für Experimental Software Engineering, Kaiserslautern

Fraunhofer IIS
Institute for Integrated Circuits, Erlangen/Nuremberg

Fraunhofer IISB
Institute for Integrated Circuits and Device Technology, Erlangen

Fraunhofer IIS
Division Engineering for Adaptive Systems EAS, Dresden

Fraunhofer IMS
Institute for Microelectronic Circuits and Systems, Duisburg

Fraunhofer IZM
Institute for Reliability and Microintegration, Berlin

Fraunhofer ITWM
Institute for Industrial Mathematics, Kaiserslautern

Fraunhofer-Gesellschaft, Munich

Imprint

Fraunhofer Institute for Integrated Circuits IIS
Am Wolfsmantel 33
91058 Erlangen, Germany

Concept and Publisher
Angela Raguse

Editors
Angela Raguse
Katja Arnhold
Marko Harasic
Jessica Lipus
Annika Lobergh
Dr. Pablo Oliveira Antonino
Ferdinand Pscheidl
Leona Schwär
Katja Schwitale-Lohmann
Okan Yesilbas

Layout and production
Ariane Ritter

Photo acknowledgements
Page 5: ©freepik/Fraunhofer ITWM
Page 7: ©stock.adobe.com/shuo/Fraunhofer IIS
Page 9: ©Fraunhofer IIS/Paul Pulkert
Page 11: ©Fraunhofer IIS/Paul Pulkert
Page 13 ©Fraunhofer Fokus
Page 17: ©Fraunhofer IIS/Paul Pulkert
Page 19: ©istock.com/ Niclasbo/ Fraunhofer IESE
Page 21: ©pixabay/Fraunhofer IIS/Angela Raguse
Page 24: ©Fraunhofer IIS
Page 27: ©Fraunhofer IZM / Francis Viebeck
Page 29: ©Fraunhofer IZM / Volker Mai
Page 35: ©Fraunhofer IIS

Contact

Fraunhofer-Gesellschaft
c/o Fraunhofer IIS
Angela Raguse M.A.
angela.raguse@iis.fraunhofer.de