

Edge AI solutions for smart sensor and actuator applications

Artificial intelligence (AI) has been used to realize novel intelligent applications in recent years. Especially in image analysis and speech recognition, dramatic improvements have been achieved. For intelligent sensors and actuators, techniques such as deep learning networks offer new possibilities to analyze complicated patterns. Conventional Cloud AI solutions are often not suitable for industrial applications due to the necessary cloud connection and low latency requirements. In the emerging Edge AI segment, Fraunhofer IPMS offers application-specific sensor/actuator developments and its own hardware platform specialized for these applications.

R&D of Edge AI solutions

Edge AI means that AI algorithms are executed either directly on the device or on a server close to the device. This is done using data collected directly from the device - without the need to connect to the Internet or a cloud service. In this way, devices can use AI to make autonomous decisions within milliseconds.

Such AI solutions are particularly relevant for industrial applications where a reliable cloud connection cannot be guaranteed. Edge AI systems need to be optimized in terms of

computational depth and power consumption, e.g., large neural networks are not sufficiently feasible in these application scenarios. Optimized and energy efficient solutions need to be deployed.

Based on broad experience in sensor/actuator and system development, Fraunhofer IPMS covers the complete range from conception to development (including training and validation) and integration for innovative Edge AI product developments.

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Demonstrator: Edge AI based gesture control

Simple hand gestures like swiping, dragging or tapping have become commonplace due to the popularity of the smartphone. However, these types of gesture control require access to a touchscreen. Touchless solutions for human-machine communication are needed in cases where a touchscreen is not available or hands and fingers cannot be used. In particular, systems that help with speech recognition and interpretation are already growing in popularity. However, these systems rely on quiet environments without external noise and are sometimes unsuitable for use in public areas. Researchers at Fraunhofer IPMS are working on an alternative approach to non-contact, three-dimensional sensing of distance, motion, and gesture for communication with robots as well as in surgical areas and household systems.

The use of an Edge AI solution offers a reliable and cost-effective solution for the analysis and recognition of user gestures. Fraunhofer IPMS is demonstrating these capabilities. Based on an ultrasonic transmitting actuator and 3 distributed receiving MEMS microphones, the gestures are measured with a repetition rate of 150 Hz. To analyze the gestures, the system uses Long Short-Term Memory (LSTM) networks optimized for use on hardware platforms for portable applications such as the RISC-V processor IP core EMSA5.

In the demonstrator, the network was trained with about 10,000 gestures to enable reliable recognition. During operation, the system enables continuous training to allow easy adaptation to user-specific gestures.

The systems demonstrate the power of modern data analytics based on Edge AI solutions. Fraunhofer IPMS offers such sensor- and actuator-based solutions to solve innovative industrial customer edge applications.

RISC-V processor IP core EMSA5

In addition to Edge AI sensor solutions, Fraunhofer IPMS also develops the hardware basis for Edge AI solutions and offers ready-to-use, platform-independent IP core modules. With IP modules, developers can quickly integrate complete functional areas into standard products such as SoCs, microcontrollers, FPGAs and ASICs.

The EMSA5-GP RISC-V Processing Core is a RISC-V compatible processing unit that supports the RISC-V 32-bit integer ISA and privileged instruction set. The design principle is a small footprint and the highest achievable clock frequency, making the core suitable as an embedded controller. Developers using the EMSA5 processor core can leverage open-source development environments (IDE), test tools and libraries, including the GNU toolchain and the comprehensive Eclipse IDE with OpenOCD debug support. Additionally, EMSA5 is supported by the Embedded Workbench of IAR Systems and by Lauterbach's TRACE32® toolset.

The EMSA5 GP core is suitable for deeply embedded applications, edge computing, embedded IoT, Edge AI, networking and communications.

To support Edge AI solutions, Fraunhofer IPMS Institute has ported Tensor low lite to the EMSA5 RISC-V. Thus, the EMSA5 RISC-V processor core is now ready for use in edge AI applications, such as sensor data analysis, gesture control or vibration analysis.