RESEARCH NEWS

Autonomous robot systems

Perfect Human-Machine Collaboration With NeurOSmart

How can we achieve intelligent teamwork between humans and robots in production? The Fraunhofer NeurOSmart technology platform combines sensor technology with AI-supported data processing and energy-efficient chips that mimic the way the human brain works.

Robotics technology that not only performs simple tasks but also supports humans in all their tasks is among the key technologies in industrial manufacturing. But this requires that robots be able to master complex movements, execute commands and maintain a safe distance from humans at all times. Fraunhofer researchers have now made this form of collaboration between humans and machines possible in the NeurOSmart flagship project.

The researchers are combining several technologies: a sensor system with LIDAR lasers that continuously monitors the work area shared by humans and robots; AI-supported chips that evaluate signals directly in the sensor system; and neuromorphic chip technology that functions like the human brain and is therefore highly energy efficient.

In addition to the Fraunhofer Institute for Silicon Technology ISIT, project participants also include the Fraunhofer Institute for Photonic Microsystems IPMS, the Fraunhofer Institute for Microelectronic Circuits and Systems IMS, the Fraunhofer Institute for Machine Tools and Forming Technology IWU and the Fraunhofer Institute for Intelligent Analysis and Information Systems IAIS.

NeurOSmart was coordinated by Fraunhofer ISIT. "Together with our project partners, we have further developed the technologies and integrated them in an overall system. Collaboration with the machine is risk-free for humans," says Shanshan Gu-Stoppel, Head of Optical Systems at Fraunhofer ISIT and honorary professor of microtechnology at the FH Westküste University of Applied Sciences in Heide.

LIDAR laser sensor system

The sensor system monitors the area in which humans and robots move from a bird's eye view. The researchers make use of a LIDAR (light detection and ranging) laser. This type of laser emits short pulses in the near-infrared range and uses the reflections to measure distances in 3D. Movable MEMS (microelectromechanical systems) mirrors project the laser across the entire work area and generate a high-resolution 3D image. The researchers have succeeded in improving the performance and energy efficiency of

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the mirrors. “We use piezoelectric aluminum scandium nitride (AlScN) with a layer thickness of only 1 micrometer for the MEMS mirrors,” explains Gu-Stoppel.

A key feature of NeurOSmart is the direct integration of data processing into the sensor system. The large amount of image data generated by the sensor's wide field of view is first preprocessed. AI-based algorithms developed by Fraunhofer IMS bundle the incoming signals and identify areas of special interest in the scene. The sensor can then be precisely aligned for subsequent analyses, saving power and reducing the data rate.

Neuromorphic computing

The next step, comprising actual evaluation of the data that serves as the basis for controlling the robot, is also performed directly in the sensor system. Under the direction of Thomas Kämpfe, Business Unit Head at the Center Nanoelectronic Technologies (CNT), researchers at Fraunhofer IPMS are focusing on the concept of neuromorphic computing. They have developed a special accelerator chip. The processor consists of many small computing units that are interconnected on a wafer in a matrix. Each chip acts as a thinking cell and makes its own decisions. This technology is based on the way the human brain works—hence the term neuromorphic computing.

Fraunhofer IAIS is developing the highly specialized AI models required for this. Only a few milliseconds elapse between signal reception, evaluation and the mechanical response of the robot arm. This enables safe collaboration even with heavy-duty robots, which the AI slows down or stops when a person comes too close. By simulating the entire robot cell, Fraunhofer IAIS was able to simulate hazardous situations for training purposes that cannot be replicated in real life.

“Neuromorphic computing is a major step towards a hardware architecture for processing resource-intensive AI applications that is not only fast but is also highly energy-efficient,” says Thomas Kämpfe. Fraunhofer ISIT researcher Gu-Stoppel adds: “NeurOSmart's technologies not only make industrial production more agile and efficient, they also make the factory floor a safe, creative and human-friendly place for all employees.”

Customized applications for industry

The NeurOSmart components and methods form a standardized technology platform. Industrial customers could develop their own applications for their individual scenarios.

In the future, NeurOSmart's energy-efficient technologies and the resulting longer battery life could also find applications in drones or sensor systems for agriculture.

Fraunhofer NeurOSmart flagship project

Project goal:
High-performance, energy-efficient data processing close to the sensor

Applications:
Robotics systems in industry, mobile systems

Project partners:

Fraunhofer Institute for Silicon Technology ISIT
Project coordination, development of piezoelectric and ferroelectric materials, MEMS mirrors

Fraunhofer Institute for Photonic Microsystems IPMS
High-performance chips (HPC), memory technology

Fraunhofer Institute for Microelectronic Circuits IMS
AI-supported data preprocessing, system integration, sensor system with LIDAR laser

Fraunhofer Institute for Machine Tools and Forming Technology IWU
Evaluation of the innovative sensor system in human/robot collaboration

Fraunhofer Institute for Intelligent Analysis and Information Systems IAIS
Development of highly efficient AI models specialized for deployment on neuromorphic hardware for person detection

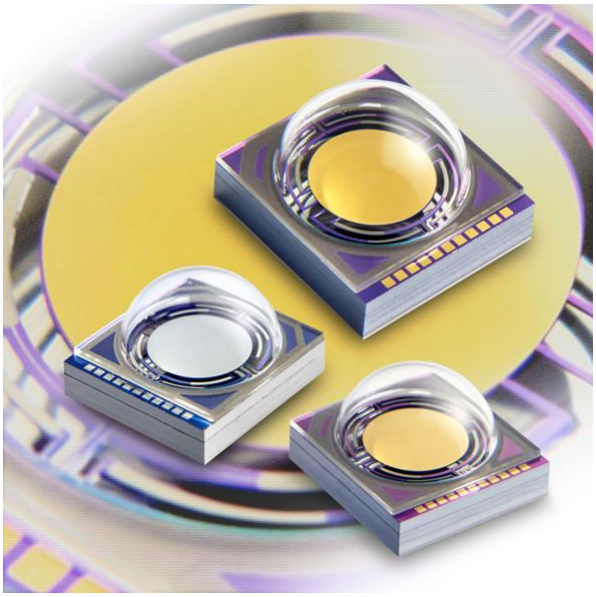

Fig. 1 The movable MEMS mirrors project the LIDAR laser across the entire work area. The reflection of the laser pulses creates a high-resolution 3D image of the work area shared by humans and robots.

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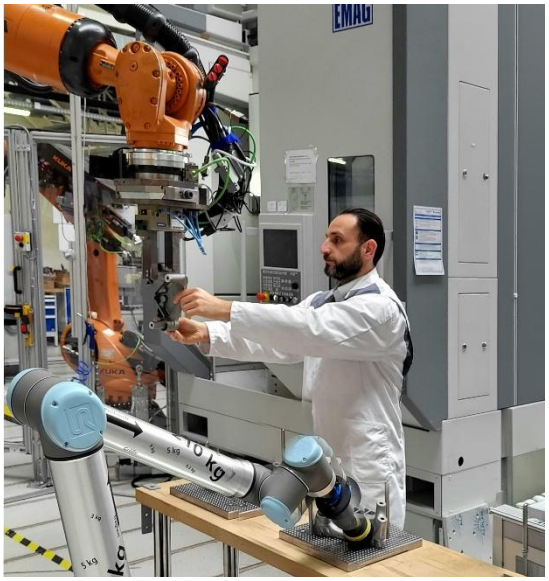

Fig. 2 With intelligent sensor technology and AI-supported data processing, NeurOSmart technology enables close collaboration between humans and robots.

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