FRAUNHOFER INSTITUTE FOR PHOTONIC MICROSYSTEMS IPMS

PRESS RELEASE

PiCASo maps its surroundings and locates gas leaks using ultrasound

Compact ultrasonic sensor lets robots “hear” their surroundings

Researchers at the Fraunhofer Institute for Photonic Microsystems IPMS and Cosys-Lab at the University of Antwerp have developed PiCASo, a particularly compact ultrasonic sensor for robotics. It can actively map its surroundings using sonar and, in a second operating mode, locate acoustic anomalies such as pressurized gas leaks. The system thus combines environmental perception and condition monitoring in a single sensor.

Autonomous robots often use cameras or LiDAR systems for navigation. The latter map their surroundings using laser light. However, dust, smoke, fog, poor lighting or limited visibility can push these systems to their limits. PiCASo complements optical perception with ultrasound: much like bats, the sensor emits sound waves and analyzes the returning echoes to map its surroundings.

Two functions in one compact sensor

At the heart of the system is a micromachined ultrasonic transducer (L-CMUT) developed at Fraunhofer IPMS. Measuring just 4 × 4 millimeters, the transducer covers a broad frequency range of approximately 20 to 80 kilohertz. It is combined with 16 miniaturized digital microphones arranged in a circle. The complete system, including its housing, measures just 35 × 38 × 15 millimeters, making it well suited for integration into compact robotic systems.

What sets the system apart is its combination of two operating modes. In active mode, PiCASo emits ultrasonic signals and uses their echoes to spatially map objects and structures in its surroundings. In passive mode, the 16 microphones capture ultrasonic signals from the environment. These measurements can be used, for example, to determine the positions of pressurized gas leaks.

Mapping surroundings and locating leaks

In experiments, the research team investigated a compressed-air conduit with three defined leak sites. PiCASo was able to spatially distinguish all three sites, including the smallest leak investigated, which had a diameter of 0.3 millimeters.
Active environmental perception was also tested indoors. Using the reflected ultrasonic signals, the system generated acoustic images of its surroundings at distances of up to

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6 meters. These images made it possible to identify and spatially locate walls, a passageway, radiators and other objects. This echo-based perception can support autonomous navigation in robots and uncrewed vehicles, drawing on the principle of echolocation that bats use to navigate their surroundings.

"Our priority is to pack as much sensing capability as possible into the smallest possible space," explains Dr. Sandro Koch, Head of the Acoustic Sensors and Systems business unit at Fraunhofer IPMS. "PiCASo demonstrates the potential of broadband ultrasound for compact robotic systems. The technology enables robots and autonomous systems to precisely map their surroundings, reliably detect objects and navigate safely even in unfamiliar environments. This allows them to respond flexibly to different situations."

Part of this work is funded by the Federal Ministry of Research, Technology and Space (BMFTR) through the iCampus 2 project.

Presentation at the SII 2027 conference in Japan
The research findings will be presented under the title "PiCASo: A Miniature Dual-Mode Acoustic Sensor for Ultrasonic Robotic Perception" at the 2027 IEEE/SICE International Symposium on System Integration (SII 2027). The conference will take place in Kobe, Japan, from January 11 to 14, 2027.

About Fraunhofer IPMS
Fraunhofer IPMS is a leading international research and development service provider for electronic and photonic microsystems in the application fields of Smart Industrial Solutions, Bio and Health, Mobility as well as Green and Sustainable Microelectronics. Research focuses on customer-specific miniaturized sensors and actuators, MEMS systems, microdisplays and integrated circuits as well as wireless and wired data communication. The institute develops systems and components on 200 and 300 mm wafers in its state-of-the-art clean rooms. Services range from consulting and design to process development and pilot series production.

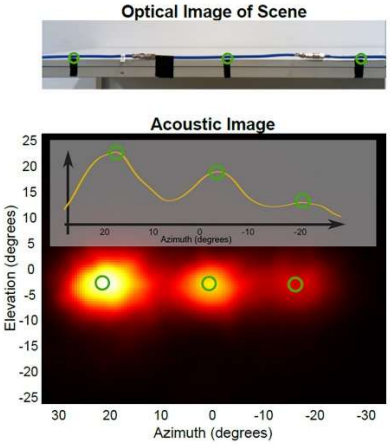
About Cosys-Lab
Cosys-Lab at the University of Antwerp researches and develops intelligent systems that combine sensors, software and physical components. Its research ranges from new sensor technologies and embedded systems to the modeling and energy-efficient design of machines. Applications span industry, mobility, agriculture and medical technology. One focus is acoustic environmental perception, for example for robot navigation and gas leak detection.

The Fraunhofer-Gesellschaft, headquartered in Germany, is one of the world's leading organizations for applied research. It plays a major role in innovation by prioritizing research on cutting-edge technologies and the transfer of results to industry to strengthen Germany's industrial base and for the benefit of society as a whole. Founded in 1949, the Fraunhofer-Gesellschaft currently operates 74 institutes and research units throughout Germany. More than 30,000 employees, predominantly scientists and engineers, work with an annual business volume of 3.6 billion euros; 3.2 billion euros of this stems from contract research.

Images



The compact PiCASo ultrasonic sensor consists of two circuit boards in a 3D-printed housing. The system measures 35 × 38 × 15 millimeters.
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In the experiment, PiCASo locates three leak sites (0.8, 0.4 and 0.3 millimeters in diameter) in a compressed-air pipe. Top: photograph of the leak sites. Bottom: acoustic image showing three distinct leak sites.
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