Fraunhofer

RESEARCH NEWS

Safer human-robot collaboration

Radar with 360° vision

Nowadays it is impossible to imagine industry without robots. Safety laser scanners mostly safeguard dangerous areas and protect people from collisions. But optical sensors have their limitations, for instance when plastic surfaces, dust or smoke obstruct their line of sight. Fraunhofer researchers have developed a new, high-frequency radar scanner that cuts through these obstacles. The ingenious twist is that it detects its environment in a 360-degree radius, making it ideal for safety applications wherever people and robots work together.

Increasing connectivity of production systems in "smart" industry 4.0 operations is driving the interaction between people and machines. The trend is moving towards industrial robots that operate without protective barriers. A prerequisite for this level of co-working is that people must not be endangered at any time – but that is precisely the Achilles' heel of collaboration between people and robots. Currently, laser scanners are used to monitor the danger zone around machinery, and to stop the machine as soon as a person enters the zone. However, optical sensors do not always achieve reliable results under changing light conditions. They also do not work if smoke, dust or fog obstructs the line of sight.

Researchers at the Fraunhofer Institute for Applied Solid State Physics IAF have developed a compact modular 360-degree radar scanner that is superior to optical sensors in many respects. This makes it a perfect choice for safety applications for human-machine collaboration. The radar works with millimeter waves that are reflected off of the objects to be observed, such as people (see box: Radar with 360-degree vision). Transmitted and received signals are processed and evaluated using numerical algorithms. Based on the calculations, it is possible to determine the distance, position and speed of the objects. If several radar units are used, an object's location in the room can also be determined as can the direction in which it is moving.

"Our radar is not focused on one point. Instead, it sends out millimeter waves in a club shape. Unlike a laser scanner, the signals are reflected even when visibility is obstructed by an object," explains IAF scientist Christian Zech. The laser scanner can measure distance and correctly calculate the position of a target – a person, for instance – only if the target is working in an unobstructed area. However, IAF's 360-degree radar can optically penetrate non-transparent material (see box), which means it can identify the employee even if there are boxes, cardboard walls or other obstacles in the way.

Editorial Notes
Beate Koch | Fraunhofer-Gesellschaft, Munich | Communication | Phone +49 89 1205-1333 | presse@zv.fraunhofer.de
Michael Teiwes | Fraunhofer Institute for Applied Solid State Physics IAF | Phone +49 761 5159-450 | Tullastrasse 72 | 79108 Freiburg | www.iaf.fraunhofer.de | michael.teiwes@iaf.fraunhofer.de

High-frequency circuit technology for cost-effective systems

Previous millimeter wave radar systems – based on wave guides – are bulky and expensive. IAF's scanner has a diameter of only 20 centimeters and is 7o centimeters high. Located in the base of the device, the high-frequency module featuring indium gallium arsenide semiconductor technology is no larger than a pack of cigarettes. "These days, millimeter applications are dominated by wave guides that are extremely expensive to produce. Thanks to a cost-effective assembly and joining technique and specially developed circuit boards, we can replace the wave guides with our high-frequency module that can be integrated onto a board measuring just 78 x 42 x 28 millimeters," says Zech. The high-frequency module, which is at the heart of the radar scanner, was developed by IAF researchers in close collaboration with the Fraunhofer Institutes for Reliability and Microintegration IZM and for Manufacturing Engineering and Automation IPA.

In addition to the signal processor, the complete system comprises a transmitting and receiving antenna with a dielectric – that is, electric but non-conducting – lens. A self-turning mirror affixed at a 45 degree angle deflects the millimeter waves, guides them, and evaluates the entire room. Thanks to the use of a dielectric antenna, the angle of aperture can be freely selected. That means recorded data can cover nearby objects as small as a centimeter in size just as easily as large surfaces that are far away. The system's range is dependent on the application and can be used at an operating distance of several hundred meters. The scanner includes an Ethernet interface and is therefore suitable for industry 4.0 applications.

Precise distance measurement

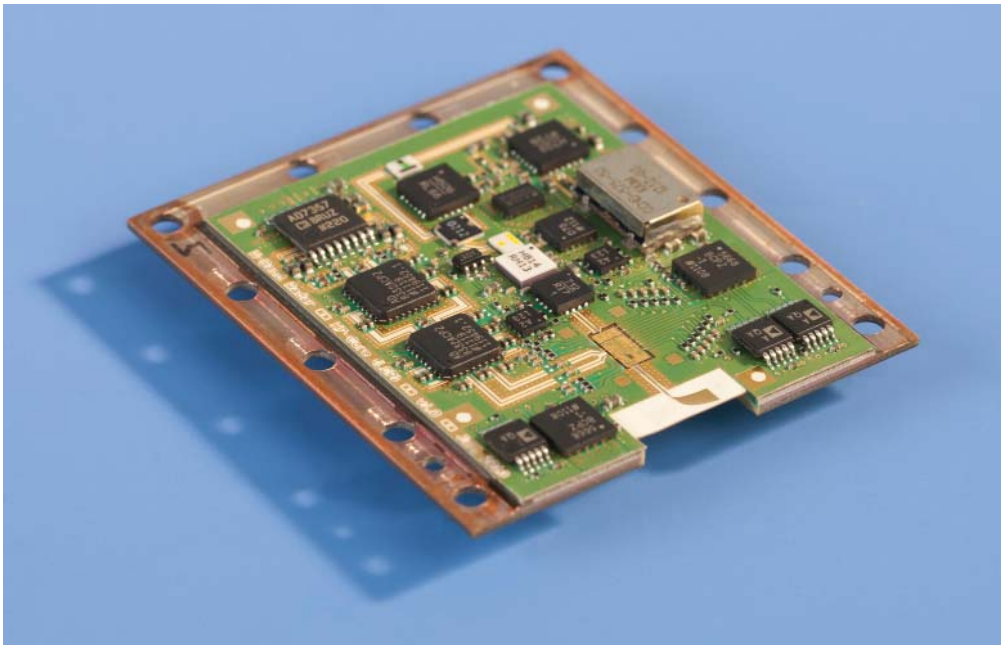
In order to test the measurement accuracy and reliability of the 360-degree radar, the researchers carried out hundreds of measurements in the lab. Maximum deviation from the mean was less than a micrometer; standard deviation was 0.3 micrometers. The researchers will present a system demonstrator at Hannover Messe (Hall 2, Booth C16/C22) from April 25-29, 2016 and again at the SENSOR+TEST in Nuremberg (Hall 5, Booth 5-248) from May 10-12, 2016.

Millimeter waves penetrate cardboard, fabrics and more

The human eye cannot see through wood, paper, or plastic. But a radar device developed by the Fraunhofer Institute for Applied Solid State Physics IAF now makes it possible to see the invisible: The radar works with millimeter waves at a frequency of 94 GHz and a bandwidth of 15 GHz. In contrast to optical sensors, millimeter waves penetrate all dielectric materials, and therefore optically non-transparent materials, such as clothing, plastic surfaces and paper, but also dust, rain, snow and fog. This makes it possible to use the W band – that is, the frequency range between 75 and 110 GHz – to detect small objects several kilometers away, even in conditions with poor visibility. The higher the frequency and bandwidth, the better the spatial resolution. The system's distinctive feature is that it detects and visualizes its surroundings in a 360-degree view, making the scanner suitable for a broad range of applications – from area monitoring and access surveillance to industrial sensor technology, logistics and flight safety through to non-destructive materials testing.

The radar module is no larger than a pack of cigarettes. © Fraunhofer IAF | Picture in color and printing quality: www.fraunhofer.de/en/press.

Fraunhofer



Thanks to a cost-effective assembly and joining technique and specially developed circuit boards, the high-frequency module could be integrated onto a board measuring just 78 x 42 x 28 millimeters. © Fraunhofer IAF | Picture in color and printing quality: www.fraunhofer.de/en/press.

The complete radar scanner: the radar module is located in the lower silver area; the mirror is attached on the top. © Fraunhofer IAF | Picture in color and printing quality: www.fraunhofer.de/en/press.

The **Fraunhofer-Gesellschaft** is the leading organization for applied research in Europe. Its research activities are conducted by 67 Fraunhofer Institutes and research units at locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of 24,000, who work with an annual research budget totaling more than 2.1 billion euros. Of this sum, more than 1.8 billion euros is generated through contract research. More than 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Branches in the Americas and Asia serve to promote international cooperation.