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High-tech Radar Solutions Made in Germany: From Contactless Vital Sign Sensing to Imaging Radars with Changeable Antennas

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Summary:
This paper introduces selected innovations and the potential of modern radar systems in different use-cases. It focuses on the developments of the German radar start-up Sykno GmbH from Erlangen.

Keywords: radar sensing, 3D-printed antennas, vital sign detection, miniaturized radars

Motivation

Since the beginning of the 20th century, radar technology has evolved from an early demonstrator for detecting ships on the Rhine river to modern, high-performance sensors. This development was enabled by the development of integrated circuits (ICs) and the resulting reduction in both cost and size. Historically, integrated radar systems experienced a significant boost due to advanced driver assistance systems (ADAS) and other radar applications in the automotive industry. This was followed by sensor solutions in industry and medicine, for which authorities allocated license-free frequency bands (ISM bands).

The young company Sykno GmbH from Erlangen, Germany, specializes in the design of radar systems tailored to customer-specific applications across a wide range of industries. With a strong foundation in advanced sensor technology and signal processing, the company delivers innovative radar solutions wicht meet the unique requirements. In the following, the potential of radar technology is summarized and selected innovations by Sykno are presented in detail.

Radar technology

Modern radar technology allows to detect several target properties remotely. Those are, in particular, 3D target position, target speed and target reflectivity (size). This is achieved by transmitting an electromagnetic wave, typically in the microwave frequency range, and receiving the reflections from the scene. A comparison between both signals at the receivers allows to extract the desired information. Due to the nature of electromagnetic waves, radar sensing is not dependent on ambient light, invisible to the human eye and can be operated in harsh environments with dust and moisture, making it perfectly suitable for outdoor and industrial applications. In addition to the established applications such as airspace surveillance, these unique features have brought radars into new applications in automation, medical technology, security, and further specialized fields.

A new level of modularity

Imaging radars, i.e. systems which offer an angular resolution in one or two dimensions, are also called MIMO (multiple input, multiple output) systems since the combined processing of multiple transmit and receive channels forms a so-called virtual array. The spacings and positions of the physical antennas as well as their radiation patterns define the system's angular resolution in elevation and azimuth plane. Typically, these antennas are realized as planar patch antennas on PCB, which, once designed, cannot be modified anymore. First, this makes the development and prototyping process very time-consuming and expensive since iterative redesigns of the entire radar front-end are required. Second, patch antennas only offer a limited bandwidth and field of view, limiting the full potential of the radar system. To overcome these issues, Sykno brought a novel strategy with interchangeable, 3D-printed antennas into products. As shown in Fig. 1, the radar system is modular, meaning that the antenna component can be easily exchanged. By using the unique 3D-printing technology from the partner Golden Devices GmbH, almost arbitrary antenna shapes can be realized. Thanks to optimized waveguide transitions, the small insertion losses in combination with the wide bandwidth supported (for example 5 GHz in the 60 GHz ISM band) outperform patch antenna-based frontends.

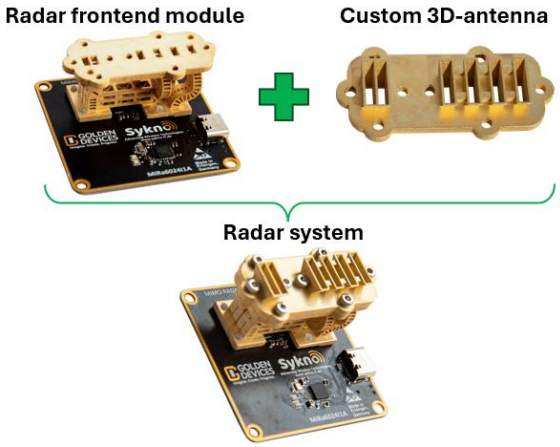

Fig. 1: Modular radar system. A 3D-printed antenna component can be exchanged without any modification of the front-end.

Contactless vital sign detection

With its product ViRa24, Sykno offers a highly precise radar system for the measurement of the human vital signs. In contrast to conventional systems, such as the wired ECG, the system detects the following, tiny skin surface movements and vibrations, which are caused by cardiac and respiratory motion:

- Respiration: 0.5 – 15 mm
- Heartbeat: 10 – 500 µm
- Heart sound: 0.8 – 50 µm

Due to its high measurement precision, even the heart sounds can be detected, making ViRa24 unique. As shown in Fig. 2, the system can be placed, for example, invisible underneath a patient bed. Since it penetrates mattresses and clothes and works in any position and rotation of the patient, it is very easy to install and does not require any maintenance, saving previous personal resources and increasing the patient's comfort.

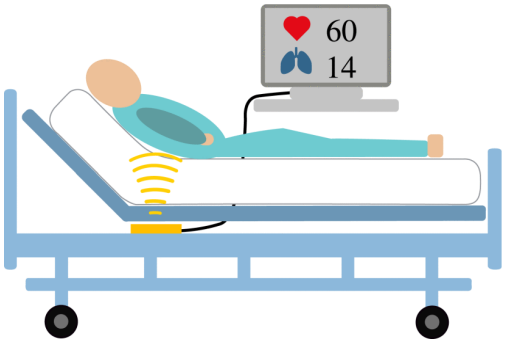

Fig. 2: Exemplary vital sign sensing scenario with a radar system being integrated into the patient bed.

A comparison between an exemplary heart sound signal captured by radar and a conventional ECG is shown in Fig. 3. It is obvious that the steep edges of the radar signal allow for a very accurate timing of the heart sounds. In combination with an AI-based classification of the signals, a deeper medical analysis of the data regarding heart rate variability and further parameters is enabled. The sensing concept was successfully proven at the university hospital in Erlangen in two medical trials, where more than 10,000 hours of data were collected.

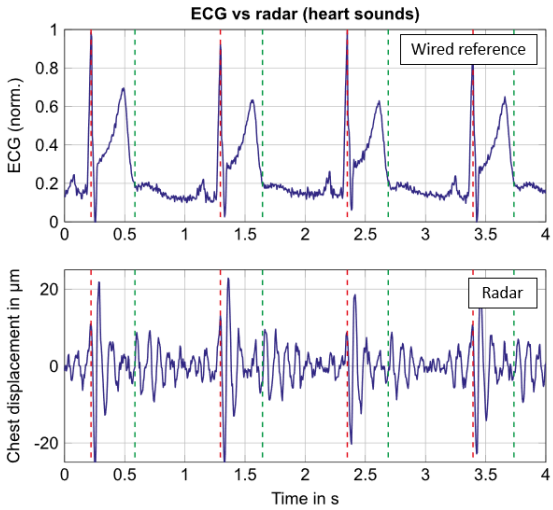

Fig. 3: Comparison of ECG reference and radar-measured heart sounds. First and second heart sounds are marked in red and green.

Miniaturized radar

Increasing transmit frequencies and novel packaging technologies have led to continuous reductions in system size and power consumption in recent years. These developments are opening the door to new applications, for instance in building automation, where it is now possible to determine the number and position of people in a room while preserving their privacy. Such information supports the smart management of lighting, air conditioning, and access control systems. For these scenarios, Sykno offers miniaturized radar modules based on chipsets from Infineon Technologies, which are operated in the 60 GHz range and are an alternative to conventional passive infrared sensors.

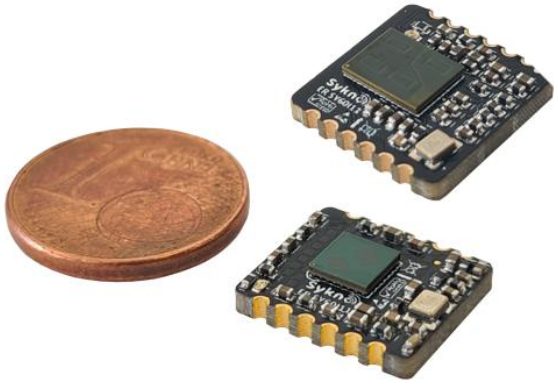

Fig. 4: Miniaturized radar modules for presence detection, gesture sensing and many more use cases.