

Radar-Based Vital Sign Sensing – The Latest Trends

Workshop abstract: During the past decade, vital sign sensing radars have become a quickly growing research topic in microwave engineering, promising the contactless and therefore patient-friendly measurement of various vital signs. This workshop explains the fundamentals of the research by introducing the underlying physiology of heartbeat and respiration, the resulting body surface movements and vibrations. System design challenges and limitations will be explained on the example of high-precision continuous-wave radars. Moreover, the challenges and outcomes of long-term studies in hospitals and home-care will be shared with the audience. Focused talks provide insights into the latest developments. This includes research in the field of passive sensing systems, which analyze ambient wireless signals, such as Bluetooth or Wi-Fi, to extract vital sign signals. Moreover, a commercial system for microwave-based blood pressure measurement will be presented, including a live demonstration.

1. Fundamentals and System Design Challenges for Radar-Based Vital Sign Sensing

Speaker: Fabian Michler

Affiliation: University Erlangen-Nuremberg, Sykno GmbH, GER

Duration: 30min + 10min Q&A

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Abstract: Advances in MMIC circuit design have enabled compact, low-cost and highly performant radar systems. A popular use-case for these systems is the contactless measurement of vital signs – offering various advantages over conventional contactless measurement methods. This talk introduces both the technical and medical fundamentals for vital sign sensing radars. Important design choices and trade-offs will be explained to understand the potential of the developed systems, but also their limitations. Exemplary systems will be presented and data obtained from medical studies will be shown.

Speaker Bio: Fabian Michler received his B.Sc. and M.Sc. degree in electrical engineering from the University of Technology in Darmstadt, Germany, in 2013 and 2016, respectively. In 2022, he obtained his PhD degree from the Institute for Electronics Engineering at the University of Erlangen-Nuremberg, Germany, where he is now leading the team Radar Systems. He has been working on continuous-wave radars for vital sign sensing, focusing on high precision radars and low-power system concepts. In 2019, he co-founded the spin-off Sykno, a company for consulting and research-oriented development of radar systems, RF components, sensor and communication systems.

2. Interferometric Radar for Cardiovascular Monitoring

Speaker: Nils Albrecht

Affiliation: Hamburg University of Technology, GER

Duration: 30min + 10min Q&A

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Abstract: Microwave Technology and especially Radar has evolved to an important tool in our life. For medical diagnostics, Radar has the potential to enable touch-free cardiovascular monitoring. But there are still several challenges to be solved. In this context a very simple Radar architecture shows superior performance: Microwave interferometry. This talk will elaborate on the fundamentals and show first clinical results of cardiovascular monitoring featuring signal quality which enable physicians to make reliable diagnoses.

Speaker Bio:

3. Observations from using mm-Wave Radars in Hospitals & Long-Term Care Homes

Speaker: George Shaker

Duration: 30min + 10min Q&A

Affiliation: University of Waterloo, CA

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Abstract: For several years, researchers have demonstrated the feasibility of using mm-Wave radars for sensing various health modalities in laboratory settings. In this talk, we share some insights from our test campaigns in hospitals and long-term care homes. We highlight some of the successes as well as some of the major challenges that face the adoption of radar technology for daily healthcare monitoring.

Speaker Bio: Prof. George Shaker is the lab director of the Wireless Sensors and Devices Laboratory at the University of Waterloo-Schlegel Research Institute for Aging. He is an (Adjunct + Research) professor with University of Waterloo at the Department of Electrical and Computer Engineering as well as the Department of Mechanical and Mechatronics Engineering. Previously, he was an NSERC scholar at Georgia Institute of Technology. He also held multiple roles with RIM's (BlackBerry). Dr. Shaker has authored/coauthored 80+ publications and 30+ patents/patent applications. His wireless systems designs can be witnessed in millions of devices in market. To date, he has received over 40 international awards and best paper recognitions for his research work on wireless sensor and communication systems.

4. Passive Radar Sensing for Motion Detection using Ambient Wireless Signals

Speaker: Aaron Carman, Changzhi Li

Duration: 30min + 10min Q&A

Affiliation: Texas Tech University, USA

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Abstract: Microwave radar has long been used to detect small physiological motions such as heartbeat and respiration. Traditionally, radar motion detection is accomplished using a monostatic system consisting of a co-located transmitter and receiver. In a medical setting, however, the presence of multiple active radar sensors can lead to unwanted interference or a high spectrum consumption as the number of patients grows. Passive radar, on the other hand, leverages ambient wireless signals such as Bluetooth or Wi-Fi in order to detect small motions, and allows for better scalability when compared to active radar without increasing bandwidth usage. In

addition, the simple architecture of passive radar sensing allows for quick and efficient scaling of the system to match the user's needs.

Speaker Bio: Aaron Carman is a Ph.D. student at Texas Tech University, with a focus on microwave radar technologies for biomedical applications. Aaron received his B.S. degree in Electrical Engineering from Texas Tech University in 2020, during which time he worked as an undergraduate research assistant under Dr. Changzhi Li. In addition, he has worked as a Student Engineer at Southwest Research Institute in the Defense and Intelligence Solutions Division. Aaron's current research interests include passive radar motion sensing, analog IC design, and radar system modeling.

5. Blood Pressure Monitoring

Speaker: Nastassia Vysotskaya

Duration: 30min + 10min Q&A

Affiliation: Infineon Technologies AG, GER

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Abstract: This presentation covers all necessary techniques how to use an FMCW radar system attached at the wrist for blood pressure monitoring. After a gentle introduction into physiological basics, optimal radar placement to improve signal quality is discussed in detail. Following that, a signal processing routing to extract the displacement signal is presented. Afterward, it is explained how the choice of radar device affects the sensor's sensitivity to motion extraction. Finally, two methods for utilizing the displacement signal to estimate systolic and diastolic blood pressure values are presented. One method is based on the pulse transit time, the other on pulse wave analysis.

Speaker Bio: Nastassia Vysotskaya was born in Minsk, Belarus, in 1998. She received her B.Sc. degree in Computational Engineering in 2020 and her M.Sc. degree in Computer Science in 2022, both from the Friedrich-Alexander-University (FAU) Erlangen-Nuremberg, Germany. After working on digital beamforming optimizations at the Department of Computer Science 3, FAU, she joined Infineon Technologies AG from 2019 to 2022 as a working student. She worked on various radar signal processing algorithms before beginning her master thesis in cooperation with Infineon Technologies about continuous non-invasive blood pressure estimation using radar technology in 2022. She is now pursuing her Ph.D. degree in radar-based vital sensing.