Application Brief

60GHz Radar Sensors Enable Better Health and Medical Care

Abstract:

This technical article explores the advancements in sensor technologies for healthcare applications. The increasing aging population and the growing demand for remote healthcare solutions have advanced the development of innovative sensor technology solutions. mmWave sensors have emerged as a promising technology for monitoring human vital signs like breathing rate and heart rate detection, and detecting the falls of the elderly people accurately. The integration of radar sensor in healthcare applications enables non-intrusive and continuous monitoring, providing valuable insights into a person's well-being. mmWave based sensors can strike a balance between data collection for healthcare purposes and preserving individual privacy. This article discusses the principles behind mmWave-based sensors, their applications in healthcare, and the potential benefits for enhancing personal care.

Radar(mmWave), traditionally associated with military and aviation applications, has found new ground in healthcare. mmWave sensors operate by emitting electromagnetic waves and detecting their reflections from surrounding objects. The raw data collected by mmWave-based sensors undergoes sophisticated signal processing and data analysis algorithms. These algorithms filter out noise, extract relevant information, and provide a clear representation of vital signs or movement patterns. Machine learning techniques further enhance the accuracy of these systems by adapting to individual variations and optimizing performance over time.

The Advantage of Using mmWave Sensor for Healthcare Applications:

Compared to other sensor modalities such as camera or PIR that are commonly used in healthcare applications, mmWave sensor has its own advantages.

- Privacy: camera is widely used for monitoring in both business and residential area. However, camera technology has privacy risk for any in-house monitoring. In contrast, an mmWave sensor only senses the motion of the target without rendering any picture that reveals personal identification, so an mmWave sensor is considered very safe for any indoor application.
- Robustness: mmWave can work in any light conditions, day or night, foggy or rain. This allows robust performance in all weather conditions.
- Aesthetics: mmWave sensor can see through most non-metallic covers, so no need to drill holes on the cover for sensing, which allows more appealing module design.
- Motion sensitivity: mmWave sensor can detect very fine velocity called "microDoppler" information. This rich velocity information carries features that can be used for performance, gesture control, sleep monitoring, vital sign monitoring and even classifying different types of objects (such as human vs. pets)
- Low power: The new generation of mmWave radar sensors, are low power and consume only as a few milliwatts, which enables convenience with a battery powered full product and avoids cumbersome power lines.

Fall detection

According to CDC, millions of fall accidents happen for people older than 65. One out of five falls causes a serious injury that requires urgent care. It is critical to report the injury on time, otherwise the patient can miss the best treatment timing window. mmWave radar can reliably detect location information, height information as well as rich velocity information which can be utilized to detect the fall accident without any delay. In the event of a fall, the sensor can trigger an alert, enabling timely intervention and reducing the risk of prolonged immobility and

any proactive management of chronic conditions. Furthermore, we know that fall accidents happen most often in the shower room. Without the privacy issue, mmWave sensor can be installed right inside the shower room and detect the fall accident even when the water is turned on. The effectiveness of fall detection anywhere in the house can be a big health assistance for elderly people who are living alone. Texas Instruments IWR6843 60GHz single chip radar sensor are deployed by several vendors to solve this application. For developers who need a lower power option, IWRL6432 is another option. Figure 2 shows the example demonstration of fall detection using IWR6843 device from Texas Instruments.

Figure 1. mmWave Fall Detection

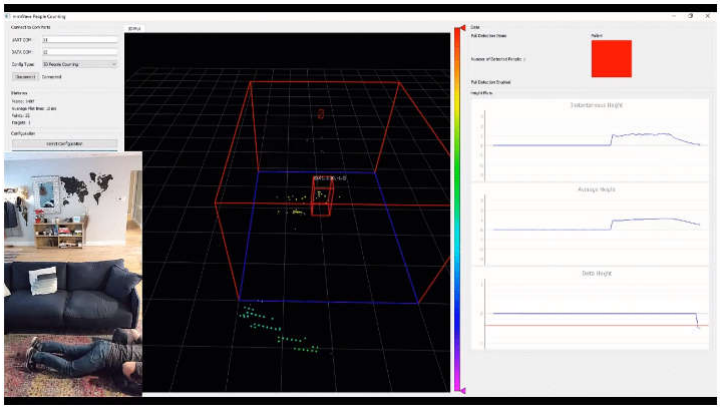

Figure 2. Detection of the Fall Event of a Person Using IWR6843 Radar

Vital Sign Monitoring

Accurate and real-time heart rate monitoring is crucial for managing cardiovascular health. mmWave-based sensors, when focused on specific areas of the body, can detect subtle chest movements associated with heartbeats and breathing. This non-contact approach eliminates the need for uncomfortable wearables, offering

a more convenient and continuous monitoring solution. This is fundamentally enabled by the Doppler effect, which alters the frequency of reflected waves due to subtle motion, as shown in below left picture in Figure 3. The top figure shows the chest displacement as the test subject breaths. The middle figure shows the breathing pattern extracted via signal processing from the chest displacement measurement. Similarly, the bottom figure shows the heart beat signal extracted from the same chest displacement measurement. Finally, the heart rate and berating rate is estimated using a frequency estimation algorithm, as shown on the right picture. Figure 4 shows the example demonstration of vital sign detection using IWR6843 device from Texas Instruments.

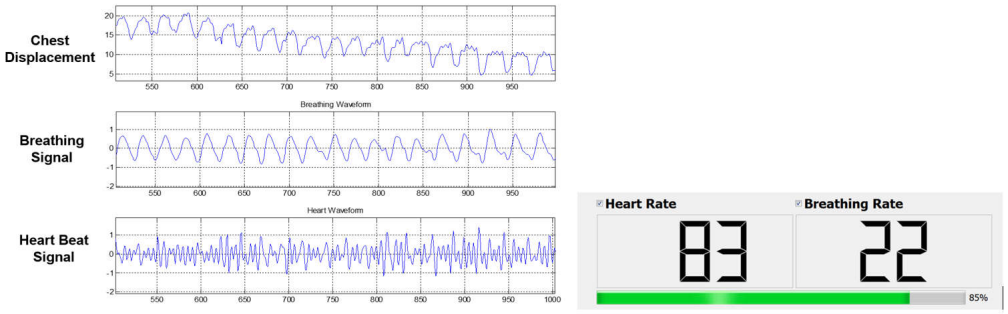

Figure 3. Chest Movement Detected by mmWave Sensor; Separate Chest Movement Into Heart Beat Signal and Breathing Signal

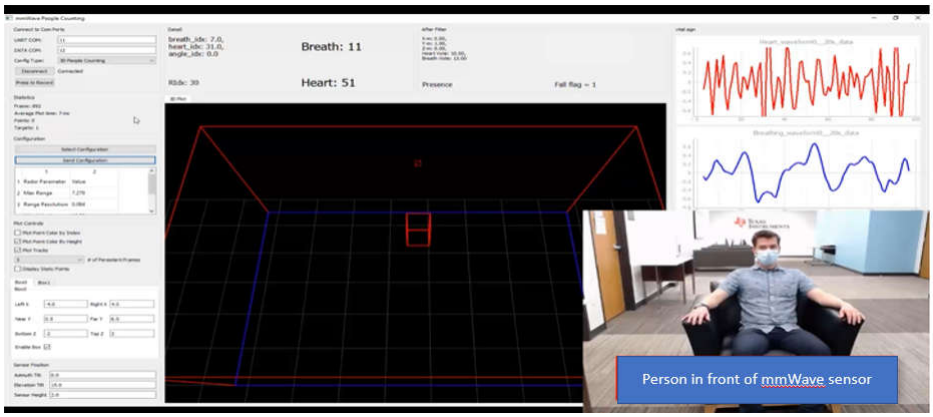

Figure 4. Demonstration Of Vital Sign Detection Using IWR6843 Device From Texas Instruments

Sleep Monitoring

Living a healthy life style is important for longevity. Knowing the sleep quote and quality is a good indication of a person's health condition. The majority of current sleep monitoring sensors are contact based, such as a belt on your wrist or chest. This can be uncomfortable to wear every day. mmWave sensor is a perfect modality that can replace these contact based sensors and achieve contactless monitoring. mmWave can sense the motion information even at a sub-millimeter level, so it can accurately detect sleep.

- When the person enters the bed according to the person's activity location
- When the person fall asleep based on the motion intensity level
- When the person falls into REM or non-REM sleep based on motion level, breathing, and heart rate pattern change
- When the person wakes up and leaves the bed

The above information can be used to generate a person's sleep report and indicate sleep quote and quality.

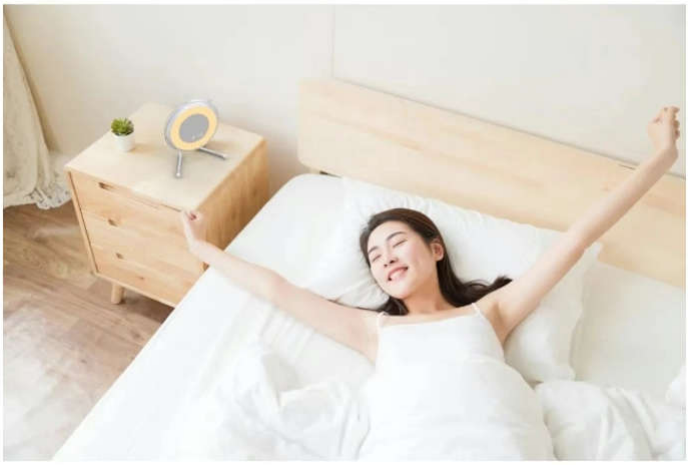

Figure 5. Sleep Monitoring Using mmWave Radar

Conclusion

60GHz mmWave-based sensors have emerged as a transformative technology in healthcare, offering non-intrusive and continuous monitoring of elderly fall detection, human vital signs, and heart rate measurement. The integration of these sensors into healthcare systems has the potential to revolutionize patient care by providing timely and accurate information for proactive interventions.

As this technology continues to advance, these sensors are becoming more integrated, accurate, and versatile, and are poised to play a pivotal role in shaping the future of remote healthcare monitoring. The sensors in each of these applications hold great promise for improving the quality of life for elderly and young alike, and addressing the challenges associated healthcare monitoring.

- Try the fall detection demo on IWR6843AOP EVM(https://www.ti.com/tool/IWR6843AOPEVM)
- Fall Detection Demo: https://dev.ti.com
- Try the vital sign estimation demo on IWRL6432BOOST EVM(https://www.ti.com/tool/IWRL6432BOOST)
- Read another white paper (https://www.ti.com/lit/pdf/swra768)
- Vital Signs Demo: https://dev.ti.com)

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