World Academy of Science, Engineering and Technology
International Journal of Electronics and Communication Engineering
Vol:18, No:02, 2024

Open Science Index, Electronics and Communication Engineering Vol:18, No:02, 2024 publications.waset.org/abstracts/175052.pdf

Contactless Heart Rate Measurement System based on FMCW Radar and LSTM for Automotive Applications

Authors : Asma Omri, Iheb Sifaoui, Sofiane Sayahi, Hichem Besbes

Abstract : Future vehicle systems demand advanced capabilities, notably in-cabin life detection and driver monitoring systems, with a particular emphasis on drowsiness detection. To meet these requirements, several techniques employ artificial intelligence methods based on real-time vital sign measurements. In parallel, Frequency-Modulated Continuous-Wave (FMCW) radar technology has garnered considerable attention in the domains of healthcare and biomedical engineering for non-invasive vital sign monitoring. FMCW radar offers a multitude of advantages, including its non-intrusive nature, continuous monitoring capacity, and its ability to penetrate through clothing. In this paper, we propose a system utilizing the AWR6843AOP radar from Texas Instruments (TI) to extract precise vital sign information. The radar allows us to estimate Ballistocardiogram (BCG) signals, which capture the mechanical movements of the body, particularly the ballistic forces generated by heartbeats and respiration. These signals are rich sources of information about the cardiac cycle, rendering them suitable for heart rate estimation. The process begins with real-time subject positioning, followed by clutter removal, computation of Doppler phase differences, and the use of various filtering methods to accurately capture subtle physiological movements. To address the challenges associated with FMCW radar-based vital sign monitoring, including motion artifacts due to subjects' movement or radar micro-vibrations, Long Short-Term Memory (LSTM) networks are implemented. LSTM's adaptability to different heart rate patterns and ability to handle real-time data make it suitable for continuous monitoring applications. Several crucial steps were taken, including feature extraction (involving amplitude, time intervals, and signal morphology), sequence modeling, heart rate estimation through the analysis of detected cardiac cycles and their temporal relationships, and performance evaluation using metrics such as Root Mean Square Error (RMSE) and correlation with reference heart rate measurements. For dataset construction and LSTM training, a comprehensive data collection system was established, integrating the AWR6843AOP radar, a Heart Rate Belt, and a smart watch for ground truth measurements. Rigorous synchronization of these devices ensured data accuracy. Twenty participants engaged in various scenarios, encompassing indoor and real-world conditions within a moving vehicle equipped with the radar system. Static and dynamic subject’s conditions were considered. The heart rate estimation through LSTM outperforms traditional signal processing techniques that rely on filtering, Fast Fourier Transform (FFT), and thresholding. It delivers an average accuracy of approximately 91% with an RMSE of 1.01 beat per minute (bpm). In conclusion, this paper underscores the promising potential of FMCW radar technology integrated with artificial intelligence algorithms in the context of automotive applications. This innovation not only enhances road safety but also paves the way for its integration into the automotive ecosystem to improve driver well-being and overall vehicular safety.

Keywords : ballistocardiogram, FMCW Radar, vital sign monitoring, LSTM
Conference Title : ICECS 2024 : International Conference on Electronic Circuits and Systems
Conference Location : Amsterdam, Netherlands
Conference Dates : February 05-06, 2024