ABSTRACT

Cardiovascular and respiratory diseases are leading causes of death worldwide, making the monitoring of vital signs such as heart rate and respiratory rate essential for early prevention. This research aims to develop a contactless vital sign monitoring system using Frequency Modulated Continuous Wave (FMCW) radar and a Denoising Autoencoder (DAE) algorithm to improve the accuracy of physiological signal estimation based on phase-extracted radar signals. The system is designed to reconstruct heart rate and respiratory rate signals from noisy and harmonically distorted radar data without requiring contact-based sensors or electrodes.

The process begins with radar signal acquisition using the IWR6843ISK-ODS sensor and DCA1000EVM module, followed by preprocessing stages including FFT, MTI, phase extraction, bandpass filtering, and segmentation using sliding windows. Ground truth data is collected using a Polar H10 heart rate monitor and Vernier Go Direct Respiration Belt. The DAE model is trained to reconstruct heart rate signals (2600 samples/second) and respiratory signals (400 samples/second), which are then converted into Beats per Minute (BPM) using frequency spectrum analysis. Evaluation results show that the best model achieved a Root Mean Square Error (RMSE) of 2.02 BPM for heart rate and 4.59 BPM for respiratory rate. System implementation in semi real-time testing yielded an average RMSE of 6.34 BPM for heart rate and 3.694 BPM for respiratory rate. This study demonstrates that combining FMCW radar with DAE provides an effective and practical solution for non-contact vital sign monitoring, with high potential for healthcare, homecare, and IoT-based monitoring applications.

Keywords: *FMCW radar, heart rate, respiratory rate, autoencoder, contactless monitoring, Denoising Autoencoder*.