Contactless respiratory rate estimation using acoustic beam forming and spectral techniques

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The monitoring of vital signs in an enclosed room poses a great challenge, as subjects may be in close proximity, making signal separation difficult. The articles presents a Direction of Arrival (DoA) and beamforming based method to address this problem. The microphones were arranged in a circular arrays to record the signals. The pre-processing was done using 10th order Butterworth filter with frequency range of 100 to 3000 Hz to suppress noise in the recorded signal. The time- frequency representation of the filtered signal was obtained using the Short Time Fourier Transform (STFT), and the spatial covariance matrix was computed to capture the inter-microphone relationships. The DoA was then estimated using steered response power with phase transform (SRP-PHAT), which guided the minimum variance distortionless response (MVDR) beamforming to extract target signal sources. The beamformed signal was then transformed back to the time domain using inverse STFT to obtain separated signals from each microphone in the circular array. Robust spectral subtraction was applied to enhance signal clarity and the respiratory rate (RR) was estimated using Hilbert transform-based envelope detection following a low-pass filter. The proposed method with tested on a database containing five classes of RR. The results showed a mean absolute error (MAE) of 4.15 bpm and a root mean square error (RMSE) of 4.64 bpm.