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Super-resolution Array Radar Imaging of Human Bodies for Heartbeat Monitoring

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1. Extended Abstract

In this study, we measured the instantaneous heart rate of one person when there were two persons standing next to each other, using a continuous wave array radar system. Both participants were located at almost the same distance from the antennas. In such a scenario, even ultra-wideband radar cannot separate the echoes from the participants if only a single pair of antennas is used. We employed an array radar system with the Capon method, a super-resolution array processing technique, to separate multiple echoes from different persons and to extract vital signs from a specific person of interest using the directionally constrained minimization of power (DCMP) algorithm.

We built an X-band radar system consisting of a four-channel network analyzer and an antenna array with wide-beam elements. We measured echoes from two participants standing in front of the antenna array using 8.4-GHz continuous wave signals and sampled every 5.0 ms using four elements of the antenna array.

Figure 1 shows the measurement scenario with two participants (A and B) standing in an anechoic chamber. They stood 60 cm apart, and 50 cm from the antenna array (left panel). A super-resolution image was generated using the Capon method (right panel). In the super-resolution image, two peaks are visible at the positions of the participants. We applied the DCMP algorithm, which suppressed the echo from participant A, while maintaining the array gain in the chest area of participant B. We successfully extracted the echo from participant B. Furthermore, we applied the topology algorithm [1] to the echo from participant B and obtained an accurate instantaneous heart rate. Using an electrocardiogram device attached to participant B, we verified the accuracy of the proposed approach in estimating instantaneous heart rate.

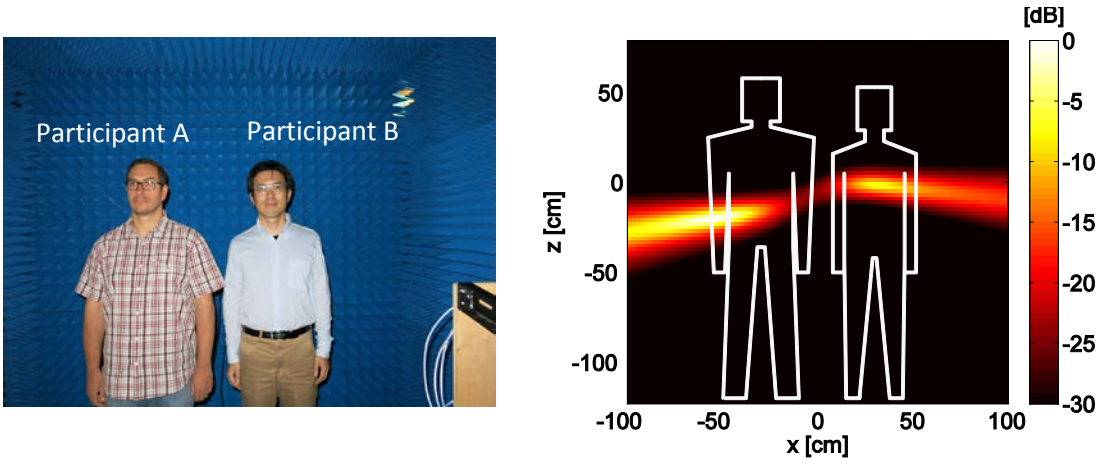

Figure 1. Participants standing in front of the four-channel antenna array radar (left). Super resolution image generated using the Capon method (right), from which the instantaneous heart rate of participant B was accurately measured.

2. References

1. Takuya Sakamoto, Ryohei Imasaka, Hirofumi Taki, Toru Sato, Mototaka Yoshioka, Kenichi Inoue, Takeshi Fukuda, and Hiroyuki Sakai, "Feature-based correlation and topological similarity for interbeat interval estimation using ultra-wideband radar," *IEEE Transactions on Biomedical Engineering*, **63**, 4, April 2016, pp. 747-757, doi:10.1109/TBME.2015.2470077.