An Result of SNR Difference in Received Antennas in mm-Wave SIMO Radar for A Remote Heart Rate Measurement

Ryota Shigihara[†], ***Student Member***, **Yaokun Hu**[†], ***Member***, **Takeshi Toda**[†], ***Member***

1. Introduction

We have investigated obstacles detection using mm-wave multiple-input multiple-output (MIMO) radar for safely bicycle riding [1], in which coherent millimeter wave radar signal were received in a linear array antenna with half wavelength spaced. However, through using the radar module for various sorts of experiments and developing signal processing, we have noticed that there was non-negligible difference in signal-to-noise ratio (SNR) in each received antenna. On the others, we have also investigated remote monitoring vital signs measurement using single-input single-output (SISO) mm-wave radar [2-5], in which a received antenna has been selected in four received antennas.

In this paper, we show the SNRs of four received antennas in a single-input multiple-output (SIMO) radar for remote heart rate measurement.

2. Radar signal processing for remote heartrate measurement

We have investigated use of discrete wavelet transform (DWT) for the remote heart rate measurement [5] shown in fig. 1. The respiration frequency is estimated with the 1st DWT from the radar vital sign signal, high pass filter (HPF) is then generated with the estimated respiration frequency. The respiration signal component in the vital sign signal is thus suppressed with the HPF, and the heart frequency with best SNR is finally extracted through 2nd DWT and the band pass filter (BPF).

3. Performance and discussion

Table 1 shows main specifications of the SIMO radar. Table 2 shows measured the SNRs of the four received antennas, in which the signal was the relative power of the estimated heart frequency and noise was total of other relative powers of the frequency points after the BPF. It was figured that the SNRs were greatly different in terms of the received antennas in each subject. We have not figured out the reason, but might be caused by the different experimental conditions of radar module and experimental setup such as radar-to-subject locations and surrounding environment, etc.

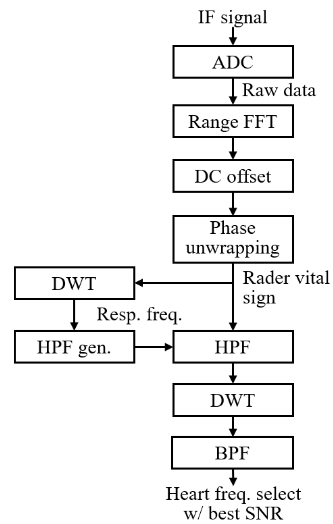

Fig. 1 Signal processing flow of heart rate measurement with DWT

Table. 1 Main specifications of SIMO radar module

Parameters	Value
Start frequency	77 GHz
Bandwidth	3.99 GHz
Received antenna array	· Four elements · Half wavelength spaced · Azimuth ±35° · Elevation ±4°
Chirp slope	70 MHz/μs
Frame time	0.1 s
Sweep time	57 μs

Table. 2 SNRs of measured heart beat frequencies in four received antennas

Subject	SNR [dB]			
	Ant. #1	Ant. #2	Ant. #3	Ant. #4
A	-16.4124	-20.6466	-17.9864	-17.7777
B	-19.1456	-17.5397	-18.1258	-16.5087
C	-18.7346	-16.8448	-20.1719	-18.6424
D	-18.6324	-20.7397	-18.1534	-16.8955
E	-14.7964	-17.7148	-20.3274	-19.6414

References

[1] K. Hirai, et al., "An Experimental Study Obstacles Detection Based on Group Tracking Method and SNR with mm-Wave Radar Supporting Safe of Bicycle Riding in Urban Bicycle dedicated Lane", 2021 Int'l Conf. on Emerg. Tech. for Commun. (ICETC2021), D2-1, Dec. 2 2021.

[2] Y. Hu, et al., "Remote Vital Signs Measurement of Indoor Walking Persons Using mm-Wave FMCW Radar", in IEEE Access, vol. 10, pp. 78219-78230, 2022.

[3] Y. Hu, et al., "The Effect of Multi-directional on Remote Heart Rate Measurement Using PA-LI Joint ICEEMDAN Method with mm-Wave FMCW Radar," IEICE Trans. Commun., vol. E105-B, No. 2, Feb. 2022.

[4] H. Shinohara, et al., "A Study of Fiducial Point as Feature for Application of Heartbeat Waveform Extracted with mm-Wave Radar to Personal Authentication", 2021 Int'l Conf. on Emerg. Tech. for Commun. (ICETC2021), P1-21, Dec. 1 2021.

[5] Sato, et al, "A Study of Frequency Selection Criteria Using Machine Learning for Heart Rate Estimation with Millimeter Wave Radar and Discrete Wavelet Transform," Technical Report MICT2021-110 (2022-03), March 2022 (in Japanese).

[†]The author is with College of Science and Technology, Nihon University, Chiyoda-ku, Tokyo, Japan, 101-0062

Copyright © 2022 The Institute of Electronics, Information and Communication Engineers

This work is licensed under a Creative Commons Attribution-NoDerivatives 4.0 International License. For more information, see https://creativecommons.org/licenses/by-nc-nd/4.0/