3. INDEPENDENT COMPONENT ANALYSIS

ICA is a method that estimates the original signal source by using only the observed data. Here, a plurality of signal sources that are statistically independent is assumed. When $N(\geqq 2)$ signal sources $\boldsymbol{s}(t) = [s_1(t), s_2(t), \ldots, s_N(t)]^T$, and N observations $\boldsymbol{x}(t) = [x_1(t), x_2(t), \ldots, x_N(t)]^T$, are expressed using the unknown transform matrix (A) by,

$$\boldsymbol{x}(t) = A\boldsymbol{s}(t) \quad (5)$$

then, in the separated modeling, the separated signal, $\boldsymbol{u}(t) = [u_1(t), u_2(t), \ldots, u_N(t)]^T$, is expressed using the separated matrix (W) by

$$\boldsymbol{u}(t) = W\boldsymbol{x}(t) \quad (6)$$

An ICA algorithm generates the separated signal $(\boldsymbol{u}(t))$ by sequentially updating the separation matrix (W) such that $\boldsymbol{u}(t)$ is statistically independent from the mixed signal $(\boldsymbol{x}(t))$. In the frequency domain, the separation model can be expressed as,

$$u(\omega, t_s) = W(\omega)x(\omega, t_s) \quad (7)$$

In this study, W is estimated by applying the FastICA algorithm to each component in the spectrogram $x(\omega, t_s)$

4. Experiments

(1) Experimental System

PSR148 by the PTM Corporation is used as the standing wave radar. Specifications of the radar are shown in Table 1. We performed the measurements in real time by inputting the response of the radar into the PC. C # is used to communicate between the radar and the PC. ICA Accord .NET Framework of Independent Component Analysis Class has been used. The measurement results are sent to the PC every 70ms. The experimental scenery is shown in figure 4. The distance between the target and the radar is 1.2 m. The heart rate was 1.19 Hz before the experiment.

Table 1. Specification of PSR148

Frequency	24.05～24.25GHz
Bandwidth	180MHz
Output	4mW
Beam width	12°(horizontal) 25°(vertical)
Sidelobe	-15dB
Aperture	30 element patch array
Range	0～100m
Range resolution	10μm or less

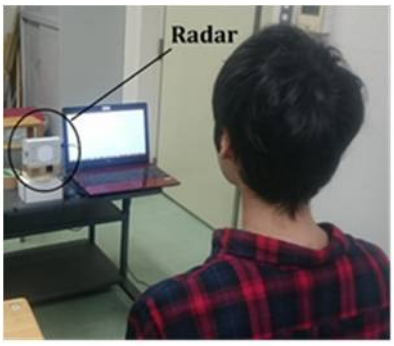
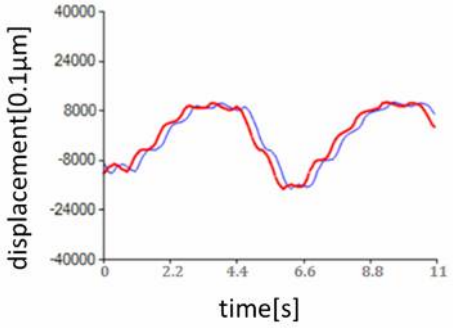


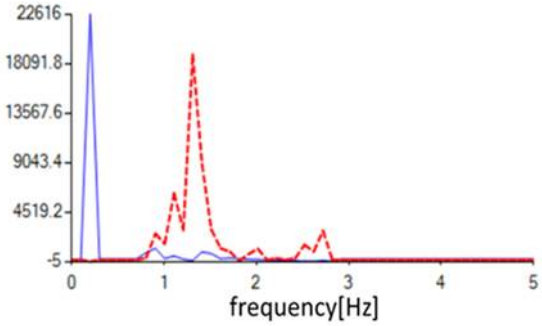
Fig.2 Experiment Scene

(2) Experimental Results

The distance measurement results in the case of a real person are shown in figure 3. In the time domain display in figure 3(a), the measurement results and 3-sample delayed waveform are overlaid. We treated these signals as two observation signals. By applying the proposed method, the spectrum clearly appears at 0.33 Hz and 1.17 Hz, as shown in figure 3(b).



(a) Measurement results (red) and 3-sample delayed waveform (blue)



(b) Spectrum for heartbeat (red) and respiratory (blue)

Fig.3 Experimental Results

5. Conclusion

By applying ICA to the standing wave radar, it was possible to detect the small heartbeat vibrations in addition to the breathing. At present, it is not possible to detect the heartbeat accurately when electromagnetic waves are not irradiated in the front upper body. In the future, we would like to perform improvements.

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