Fast Estimation Algorithm for Living Body Radar

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***Abstract* –The authors have proposed a direction estimation method of the living-body using array antenna in multi-path environment. However, this method has a problem that takes time as several tens of seconds. In this paper, we present a fast algorithm for estimating living-body direction. The experiment showed that the proposed method works well in estimating living-body direction with high accuracy in multi-path environment even when the observation time is less than conventional method.**

***Index Terms* — Array antenna, living-body radar, fast estimation algorithm.**

I. INTRODUCTION

The increase in the number of the elderly people living alone is a key issue in several countries. This has given rise to social problems such as accidental falls and lonely death. Therefore, a need for a safety-monitoring system of the elderly is growing. MIMO (Multiple-Input Multiple-Output) radar has been studied for a safety-monitoring system. The authors have proposed a direction estimation method of the living-body using array antenna in multi-path environment [1]. Though this method can estimate living-body direction accurately, it takes time as several tens of seconds to estimate target direction.

In this paper, we propose a fast estimation algorithm for living-body direction. In this method, the channel difference between the channels with different times is used, and the channel components affected by the living-body are extracted. An experiment carried out in an actual multi-path environment to validate the proposed method.

II. FAST ESTIMATION ALGORITHM FOR LIVING-BODY RADAR

In an environment where there is one person, the measured $m \times 1$ time-variant SIMO (Single-Input Multiple-Output) channel consists of the constant component waves from the wall and the varying component wave from the subject, and is expressed as,

$$\boldsymbol{H}(t) = \left[h_{11}(t), h_{21}(t), \ldots, h_{m1}(t)\right]^T , \quad (1)$$

where, h_{ij} is the complex channel response, and t represents the time of channel observation. Conventionally, living-body direction estimation has been difficult because of existence of unwanted paths such as constant component waves. Indeed, the constant component waves do not vary. Then, we define the temporally differential channel as,

$$\Delta \boldsymbol{H} = \boldsymbol{H}(t_1) - \boldsymbol{H}(t_2) . \quad (2)$$

The constant component waves are excluded from the observed channel. The direction of living-body can be estimated by applying direction of arrival estimation to (2) [2], and the estimation is realized by using two channels with slightly different moments.

III. MEASUREMENT CONDITIONS AND EXPERIMENTAL ENVIRONMENT

Fig.1 and Fig.2 show the configuration and overview photo of the measurement setup. This study uses a monostatic 4×1 SIMO configuration, where the receiver has four horizontally arranged patch antennas and the transmitter has single patch antenna which is 1.0 wavelength above the receiving array. The array's center is set to $h = 1.2$ m. The spacing between antenna elements for receiver is 0.5 wavelengths, the distance and direction from the receiver to the subject are D [m] and θ [°], respectively. Sampling frequency is set to 4.0 Hz. Single receiver system with Single-Pole 4 Throw (SP4T) switches is used to observe the SIMO channel. Transmitted power is set to 10 dBm, and 2.47125 GHz CW signal is used. The measurement was conducted in a multi-path environment where furniture and fixtures such as tables and shelves are set along the wall. Only the subject was in the room, and stood facing the antenna direction.

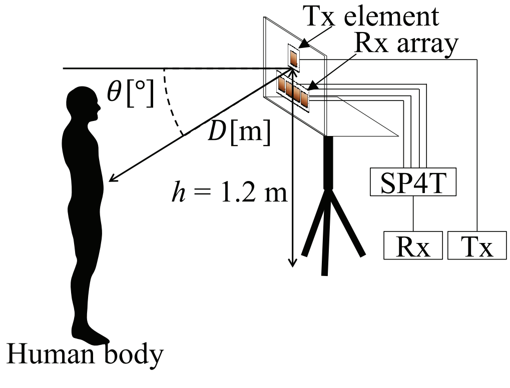

Fig.1: Measuring system configuration

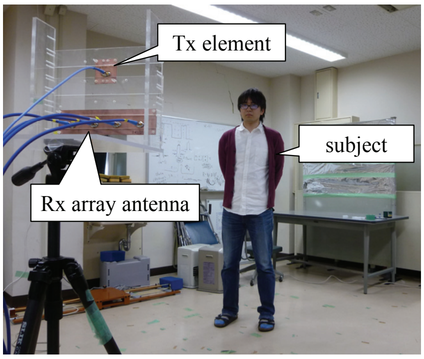

Fig.2: Measurement overview

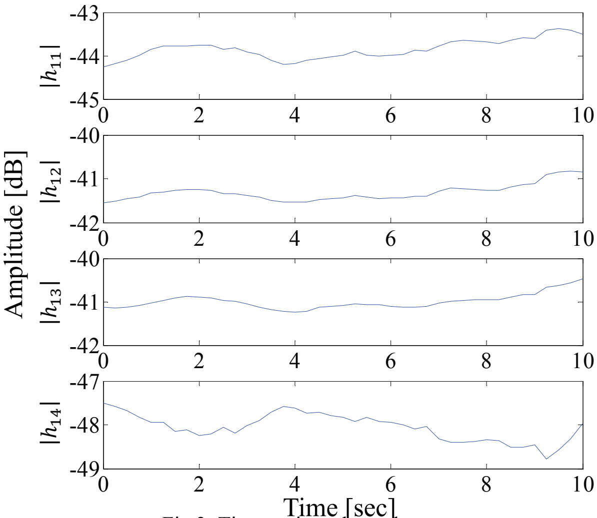

Fig.3: Time variant channel response

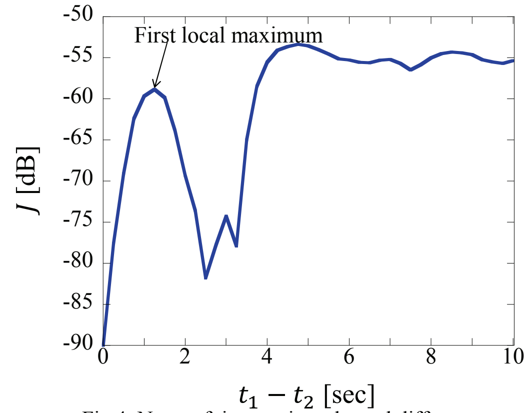

Fig.4: Norm of time-variant channel difference

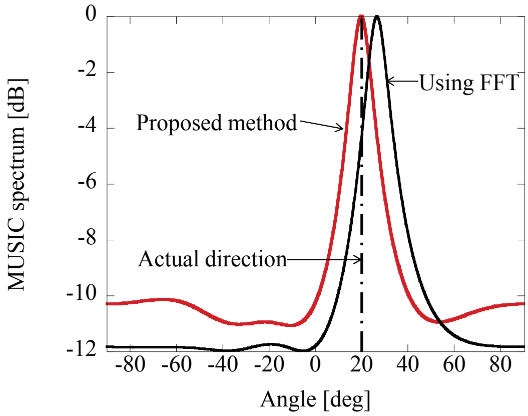

Fig.5: Result of the estimating living-body

IV. Experimental Results

Fig.3 shows the time response of the observed channel when the subject stands at $D = 2.0$ m and $\theta = 0°$. From this figure, the observed channel is varied by the influence of the living-body activity such as respiration. Fig.4 shows the channel subtraction of taking the time-variant channel distance, and the evaluation function J is expressed as,

$$J = 10\log_{10}\left\|\boldsymbol{H}(t_i) - \boldsymbol{H}(t_j)\right\|_F^2. \quad (3)$$

From this figure, we find that the peak appears at the observation interval, $t_1 - t_2 = 1.25$ s. In this study, the observation interval is determined to maximize (3).

Fig.5 shows the estimating result of living-body direction when the subject at $D = 2.0$ m and $\theta = 20°$. Then, we use the method of estimating living-body direction by applying the MUltiple SIgnal Classification (MUSIC) method in multi-path environment [2]. When the conventional method by Fourier transformation that uses the time as 1.25 sec is used, the spectrum peak appears $\theta = 26.6°$ that is near the living-body direction but this result is not within the subject's width. On the other hand, when the proposed method is used, the spectrum peak appears at $\theta = 19.8°$. This result is within the subject's width. Therefore, it is confirmed that the proposed method is effective in shortening observation time for estimating the living-body direction in multi-path environment.

V. Conclusion

This paper has proposed a fast estimation algorithm for living-body radar in multi-path environment. This method uses only two channels with slightly different moments, and the living-body direction successfully is estimated by employing the MUSIC method. An experiment confirmed that the proposed estimation algorithm works well with high accuracy even when the observation period is 1.25 s.

Acknowledgment

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References

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