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An Evaluation of the Arrangement Transmitter System by Direction of Arrival (DOA) Estimation

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Abstract:

In this research paper, we evaluate the arrangement transmitter system by Direction of Arrival (DOA) estimation plan, and on the evaluation, we make clear problems related to the hardware and transmission background of the arrangement transmitter system [1]. Arrangement transmitter systems are often modeled without any capacity and the possessions of distinction in characteristics, joint coupling, built-up mistakes, etc., are rarely deliberate. DOA estimation using an arrangement transmitter is categorized based on the principle of beam and null steering. Both methods require the steering vector of the arrangement transmitter for estimation.

Key Words: DOA, DBF, AD, In-phase, Quadrature phase, RF, Signal

I. Introduction

In this research paper, we evaluate the arrangement transmitter system by Direction of Arrival (DOA) estimation plan, and on this evaluation, we make clear problems related to the hardware and transmission background of the arrangement transmitter system [2]. Arrangement transmitter systems are often modeled without any capacity and the possessions of distinction in characteristics, joint coupling, built-up mistakes, etc., are rarely deliberate. The hypothesis or theory and measurements differ, particularly when the elements are in small number. It is needed to model the arrangement transmitter system both statistically and quantitatively based on measurements. First, we formulate the arrangement transmitter by Direction of Arrival (DOA) estimation and give details the prototype arrangement transmitter system. The prototype system has been enhanced after every evaluation. Next, an evaluation technique using a rotating arrangement transmitter system is proposed. This technique can be used to evaluate the arrangement transmitter system in detail using a rotating arrangement transmitter and Direction of Arrival estimation [3]. Further, we evaluate the error factor experimentally in an anechoic chamber.

II. Formulation of the arrangement transmitter system

First, we formulate a uniformly spaced linear arrangement transmitter ignoring mutual coupling between arrangement elements and assume that the element patterns of the arrangement transmitter are identical [4]. We consider narrow band plane waves *W*, where the center wavelength is λ, and the observed linear arrangement transmitter consists of *d* intervals with *M* transmitter elements. Figure 1.1 shows the arrangement transmitter geometry system.

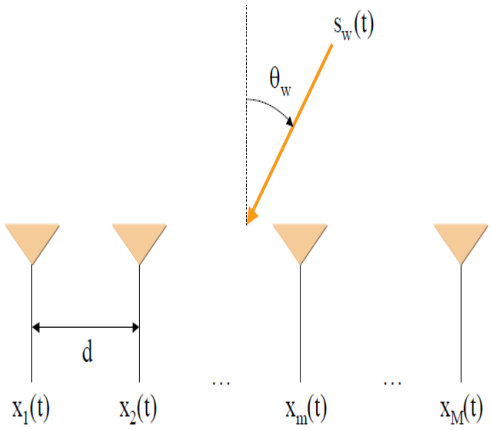

Figure 1.1: Arrangement transmitter geometry system

The output signal of the m_{th} element can be described as follows:

$$x_m(t) = \sum_{w=1}^{W} s_w(t) \cdot a_m(\theta_w) + n_m(t) \quad \text{….. (1.1)}$$

$$a_m(\theta_w) = \exp\left[j2\pi \frac{f}{c} d(m-1)\sin\theta_w \right]$$

$$= \exp\left[j\frac{2\pi}{\lambda} d(m-1)\sin\theta_w \right] \quad \text{…. (1.2)}$$

$$m = 1, \cdots, M$$

Where $s_w(t)$ and θ_w are the complex amplitude and Direction of Arrival of the w^{th} source, in that order, the vertical direction in terms of the arrangement system is assumed to be 0°, $n_m(t)$ is the normally distributed noise with mean **"0"** and variance σ^2, *f* is the carrier frequency, and *c* is the luminous flux. Equation (1.1) can be expressed using vector demonstration as follows:

$$\mathbf{x}(t) = \mathbf{A}\mathbf{s}(t) + \mathbf{n}(t) \quad \text{…… (1.3)}$$

$$\mathbf{x}(t) = \left[x_1(t) \quad x_2(t) \quad \cdots \quad x_M(t) \right]^T \quad \text{…….. (1.4)}$$

$$\mathbf{A} = \left[\mathbf{a}(\theta_1) \quad \mathbf{a}(\theta_2) \quad \cdots \quad \mathbf{a}(\theta_W) \right] \quad \text{……….. (1.5)}$$

$$\mathbf{a}(\theta_w) = \left[1 \quad \exp\left(j\frac{2\pi}{\lambda} d\sin\theta_w \right) \right. \quad \text{…….(1.6)}$$

$$\left. \exp\left(j(M-1)\frac{2\pi}{\lambda} d\sin\theta_w \right) \right]^T$$

$$\mathbf{s}(t)=\left[s_1(t)\ \ s_2(t)\ \ \cdots\ \ s_W(t)\right]^T$$ ….(1.7)

$$\mathbf{n}(t)=\left[n_1(t)\ \ n_2(t)\ \ \cdots\ \ n_M(t)\right]^T$$ …….(1.8)

Where the superscript **“*T*”** represent the transpose of the vector or matrix. $\boldsymbol{\alpha}\ (\theta_W)$ is term the “steering vector,” which show the in receipt of characteristics of the arrangement transmitter for the direction of θw [5].

Then, the arrangement correlation matrix is defined as follows:

$$\mathbf{R}_{xx}=E\left[\mathbf{x}(t)\mathbf{x}^H(t)\right]$$ ………(1.9)

$$=\mathbf{ASA}^H+\sigma^2\mathbf{I}$$

Where $E[\cdot]$ denotes the expectation operator, the superscript H denotes the compound conjugate transpose of the vector or matrix, and $\boldsymbol{S}$ is the source correlation matrix defined as:

$$\mathbf{S}=E\left[\mathbf{s}(t)\mathbf{s}^H(t)\right]$$ ………… (1.10)

The Eigen values and associated eigenvectors of $\boldsymbol{R}_{xx}$ are defined as λ_m and $\boldsymbol{e}_m$, respectively; therefore, the correlation matrix takes the following form:

$$\mathbf{R}_{xx}=\sum_{m=1}^{M}\lambda_m\mathbf{e}_m\mathbf{e}_m{}^H$$ ……(1.11)

$$=\mathbf{E\Lambda E}^H$$

Where “$\boldsymbol{E}$” is a row matrix of $\boldsymbol{e}_m$ and $\boldsymbol{\Lambda}$ is a diagonal matrix of λ_m. When correlation-ship between sources and noise has no correlation-ship with source, the Eigen values of $\boldsymbol{R}_{xx}$ are related as follows:

$$\lambda_1\geq\lambda_2\geq\cdots\geq\lambda_W>\lambda_{W+1}=\cdots=\lambda_M=\sigma^2$$ ……….. (1.12)

This implies that an Eigen value can be separated into a signal component and a noise component; defined as $\boldsymbol{\Lambda}_S$ and $\boldsymbol{\Lambda}_N$, respectively, and the corresponding eigenvectors are defined as $\boldsymbol{E}_S$ and $\boldsymbol{E}_N$, respectively. Thus, equation 1.12 can be expressed as:

$$\mathbf{R}_{xx}=\mathbf{E}_S\mathbf{\Lambda}_S\mathbf{E}_S{}^H+\mathbf{E}_N\mathbf{\Lambda}_N\mathbf{E}_N{}^H$$ ………

(1.13)

III. Formulation of DOA Estimation

The algorithm of DOA estimation using an arrangement transmitter is categorized based on the principle of beam and null steering. Both methods require the steering vector of the arrangement transmitter for estimation [6]. However, in the ESPRIT method, the steering vector of two identical sub-arrangements is already known.

Here, we formulate a representation for the MUSIC method. On comparing equations (1.9) and (1.13), a component of $\boldsymbol{E}_N$ is perpendicular to the steering vector $\boldsymbol{A}$.

$$\mathbf{e}_j^H \mathrm{a}(\theta_i) = 0$$
$$i = 1, \cdots, W$$

$$j = W + 1, \cdots, M \quad \ldots\ldots\ldots\ldots\ldots \text{(1.14)}$$

On the basis of this relation, DOA estimation is conducted with the following equation:

$$\mathrm{P}_{MUSIC}(\theta) = \frac{\mathrm{a}^H(\theta)\mathrm{a}(\theta)}{\sum_{j=W+1}^{M} \left|\mathbf{e}_j^H \mathrm{a}(\theta)\right|^2} \quad \ldots .1.15$$

The denominator is a scalar product between the steering vector and the noise eigenvector; $P_{MUSIC}(\theta)$ becomes infinite when θ satisfies equation (1.14). The plot of $P_{MUSIC}(\theta)$ with varying values of θ is called the MUSIC spectrum and the peaks represent the estimated DOA [7]. Therefore, DOA estimation by the MUSIC method has the following requirements. First, correlation of arriving waves should be low and should be absent with noise. When the correlation is high, the SSP (Spatial Smoothing Preprocessing) method is proposed in order to suppress the correlation. Second, the number of waves W should be smaller than the number of elements M. Third, accurate information regarding the steering vector $\boldsymbol{a}(\theta)$ and W should be previously available.

IV. Evaluation of prototype arrangement transmitter system

In order to verify a system by DOA estimation, an arrangement transmitter verification system with DOA estimation is proposed. In this system, DOA is varied by rotating the receiving arrangement transmitter on a rotator with a fixed transmitting transmitter, and the estimation error is verified [8]. Since the transmitting transmitter is fixed, a highly accurate verification is obtained.

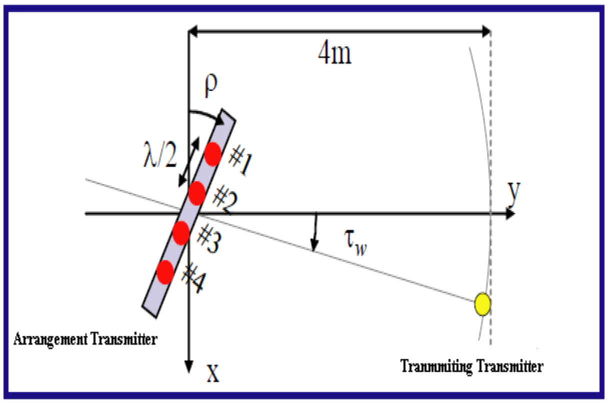

Figure 1.2: Evaluation of the arrangement transmitter system

Figure: 1.2 shows the x-y coordinate system in which the center of rotation of the getting arrangement transmitter lies at the origin, the angle of the receiving arrangement transmitter to the x axis is defined as ρ, and the direction of the transmitting transmitter to the y axis is defined as τ_w. The current DOA θ_w at the receiving point is:

$$\theta_w = \tau_w - \rho \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(1.16)}$$

For example: when the transmitting transmitter is on the "y" axis ($\tau_w = 0$), $\theta_w = -\tau_w$. The DOA estimation error δ_w is defined as:

$$\delta_w = \theta_w - \varepsilon_w \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(1.17)}$$

Where ε_w is the estimated angle.

The DBF (Digital Beam Forming) receiver is composed of cables, frequency converters, filters, etc. These characteristics differ in each channel and vary depending on time, temperature, etc. Thus, since the characteristics differ from channel to channel, it is necessary to calibrate the phase and amplitude in each channel [9]. The phase and amplitude of the received signal in each channel of the DBF arrangement transmitter were adjusted by calibration before carrying out measurements when a sine wave was transmitted to the receiving arrangement transmitter (τw = ρ = 0 in Figure 1.2). When the arriving wave is assumed to be a plane wave, the received signal in each element becomes equal. The diffusion of each transmitter element, cables, and low-cost RF circuits can be restrained by this procedure.

V. Prototype arrangement of transmitter Systems

The basic building of an arrangement transmitter system is shown in Figure 1.3. The signal received from the arrangement transmitter is converted to low frequency in the DBF receiver and stored in the PC's (Personal computer) memory used of an AD (Analog to Digital) converter. This operation is synchronously carried out for each channel. This arrangement transmitter system offers the best configuration for mobile communication since multiple patterns can be steered simultaneously [10]. It is possible to operate all adaptive algorithms and all DOA estimation algorithms using by this system for measurement. Thus far-off, we have designed some prototype arrangement transmitter systems in our laboratory and have subsequently tested and improved each one. Below lists the characteristics of the prototype receivers [11] [12]. The block diagram of the initial model is shown in Figure 1.3. In this model, the RF signal received from the arrangement transmitter passes through three steps of frequency conversion and orthogonal decay, and we obtain the In-phase and Quadrature phase signals for each element as outputs. The phase and amplitude of each channel can be separately controlled within ±90° and ±5 dB, in that order, using the controller attaché to the receiver system [13]. Previous to designing the receiver, the following points eminent:

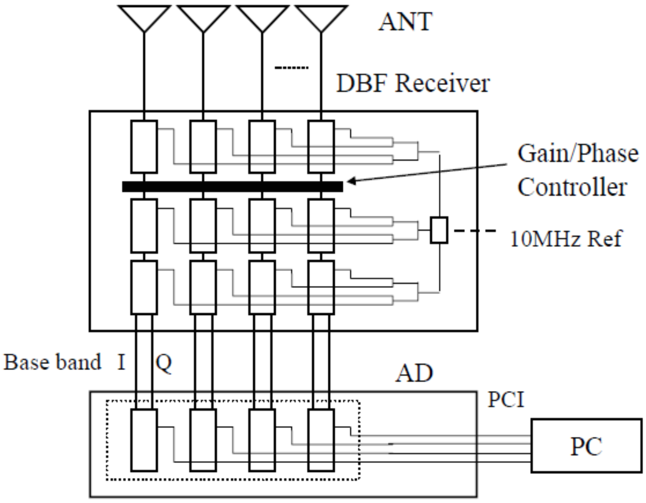

Figure 1.3: Composition of the DBF arrangement transmitter system

1. The electrical length from RF input to IQ output is kept constant between channels.

2. The phase and amplitude of the LO input to the mixer are kept constant between channels.

3. The system should be designed such that the characteristics of the circuits (phase

and gain) are not easily influenced by external factors.

4. Independent phase and amplitude adjustment circuits are installed in each channel.

However, this composition poses a problem—the phase and amplitude cannot be adjusted independently (amplitude changes when the phase is changed), the shift in the range of the phase is limited, and the orthogonality of IQ suffers due to the instability of an internal oscillator. These problems were solved by incorporating a series of improvements.

VI. Conclusion

In this research paper, we formulated the arrangement transmitter and DOA estimation and explained prototype arrangement transmitter systems. An evaluation method using a rotating arrangement transmitter is proposed. We analyzed the error factor based on experiments conducted in the anechoic chamber. We evaluated the arrangement transmitter system using DOA estimation, and on the basis of this evaluation, we clarify the problems related with the hardware and propagation environment of the arrangement transmitter system. The DOA estimation error is large due to errors from inaccuracies in the arrangement element intervals and mutual combination. These errors are not independent, and they differ with the transmitter structure design and machining correctness.

VII. References:

1. Akira Minakawa, Tadashi Matsumoto, "Effects of Steering Vector Distortion and its Compensation on DOA Estimation," IEICE technical report. Antennas and propagation, AP2000-75, pp.1-6, Sep. 2000.
2. Nobuo Nakajima, "Adaptive Array Antenna for Mobile Communications," Transactions of IEICE, Vol.J84-B, No.4, pp.666-679, Apr. 2001.
3. Hirotake Sumi, Yuki Inoue, Hiroyuki Arai, "Error of The DOA Estimation for Two Incident Wave Case", Proceedings of the Society Conference of IEICE, B-1-11, Sept. 2002.
4. C.A. Balanis, A.S. Spania, T.M.Duman and Capone, J.M., "Impact of smart antenna designs on network throughput and BER", Antennas and Propagation Society International Symposium, 2004.
5. Constantine A. Balanis, Antenna Theory: Analysis and Design, Wiley-Interscience, 2005.
6. Michael Hempel, Hamid Sharif, Wei Wang, Ting Zhou, Puttipong Mahasukhon, "A Study of Critical Baseline Performance Characteristics for IEEE 802.16e-2005", IWCMC 2008.
7. P. Mahasukhon, H. Sharif, M. Hemp el, T. Zhou, W.Wang, H.-H. Chen, "IEEE 802.11b based ad hoc networking and its performance in mobile channels", Communications, IET 2009 .

8. F. Babich, M. Comisso, A. Dorni, F. Barisi, F. and A. Mania, “The Simulation of Smart Antennas in Network Simulator-2 Using MATLAB”, Computer Aided Modeling and Design of Communication Links and Networks, 2009.

9. Junli Liang, ‘Joint Azimuth and Elevation Direction Finding Using Cumulant”, IEEE SENSORS JOURNAL, VOL. 9, NO. 4, APRIL 2009.

10. F. Babich, M. Comisso, A. Dorni and F. Barisi, “Open source simulation of smart antenna systems in network simulator-2 using Octave”, Wireless Pervasive Computing (ISWPC), 2010.

11. Puttipong Mahasukhon, Hamid Sharif, Michael Hempel, Ting Zhou, and Tao Ma, “Distance and Throughput Measurements in Mobile WiMAX Test Bed”, MILCOM 2010 .

12. H. Hatano, T. Mizutani, Y. Kuwahara, “Reduction Processing of the Position Estimation Error Using Transmitted Directivity Information,” IEICE. Transactions on Fundamental of Electronics, Communications and Computer Science, Vol.95-A, no.1, pp.286-295, 2012.

13. H. Hatano, K. Satoyoshi, R. Fujii, and Y. Kuwahara, “ Proposal of Simple Diversity Antenna for ISDB-T, ” IEICE Trans. Vol.. J95-B No.1pp.65-70, 2012.

14. N. Abdullah and Y. Kuwahara, “VHF Adaptive antenna Using the Rear Defogger” IEEE Trans. On Antennas and Propagation,” IEEE Trans. Antennas and Propagat Vol.60 No.3, pp.1228-36, 2012.

15. P. Sindhuja and Y. Kuwahara, “GA Optimization of Transparent MIMO Antenna for Smartphone,” IEICE Electronics Express, Vol.10, No.11, pp.1-8, 2013.