A Study on Multipath Coherent Signal Separation in Wireless Channel

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Abstract. In this paper, a DOA estimation method using subarray and spatial smooth is proposed. To significantly improve the robustness of DOA estimation and of beamforming and to estimate azimuth angle in multipath mobile channel environment. We developed method for applying spatial smooth subarray to arrays of arbitrary geometry. We show that can be the application of our method MUSIC and adaptive beamforming method.

Keywords: MUSIC, Spatial Smooth, Subarray, DOA, Correlation

1 Introduction

In array signal processing, direction of arrival(DOA) estimation of multiple narrowband signals is a classic problem[1]. Recently, as the mobile communication technology advances, sensor array signal processing emerges as potential technology to improve the spectral efficiency. Much of the work in sensor array signal processing had focused on methods for high resolution DOA estimation and optimum adaptive beamforming. These methods include the well-known MUSIC and ESPRIT for DOA estimation [2]. These method lead to an acceptable DOA estimation if the number of signal sources is less than the number of antenna elements. These are called by subspace method. In the case where the total number of interfering and target signal sources is larger than the number of antenna elements, only sources is larger than the number of antenna elements, only some of the DOA of the signals can be properly estimated[3]. In MUSIC method, the DOA are determined by finding the direction for which their antenna response vectors lead to peaks in the MUSIC spectrum formed by the eigenvectors of the noise subspace[4]. However, an important drawback of these techniques is the severe degradation of the estimation accuracy in DOA estimation or signal cancellation in adaptive beamforming in the presence of highly correlated or coherent signal. In this paper, we develop a general spatial smoothing method for arrays of arbitrary geometry to make MUSIC, ESPRIT method and optimum adaptive beamforming algorithms operative in a coherent interference environment and meanwhile success robustness in performance. We compare general methods with proposal methods for arrays of arbitrary geometry.

2 Estimation Signal

We consider array consisting a uniform linear array narrow band signals with additive white Gaussian noise, element spacing and consisting of identical elements. The array output covariance matrix can be written as follow[5]

$$R = E[r(t)r^H(t)] = A R_s A^H + \sigma^2 I \quad (1)$$

Where is the received signal, $(\;)^H$ is hermite matrix is steering matrix and is the variance of the white Gaussian noise. In the case of uniformly spaced linear array, with a sensor spacing, the spatial smoothing method can be applied to achieve the nonsingularity of the modified covariance matrix of the signals. This method begins by dividing a uniformly spaced linear array of sensors in overlapping subarrays of size , with sensors forming the first subarray, and sensors forming the second subarray[]

(2)

Where is steering matrix consisting of steering vectors associated with the subarray and is the power of a diagonal matrix. The spatially smoothed covariance matrix is defined as the average of the subarray covariance. can be written as follow[8]

(3)

Where is the covariance matrix associated with the subarray, is the modified covariance matrix of the signals, and has been proved to be full rank. The signals are thus progressively decorrelated. However linear arrays has limitations in the domain of estimable direction of arrivals. $\bar{R}_s$ can be written as follow

$$\bar{R}_s = \frac{1}{K} B\, B^H \quad (4)$$

Where $B = P\,A^T$ with $P = diag(p_1, p_2, \cdots, p_M)$ p_1 is $\exp(-j2\frac{\pi}{\lambda} d \sin\theta_1)$.

$$A = \begin{bmatrix} 1 & \cdots & 1 \\ \vdots & \ddots & \vdots \\ e^{-j2K\pi d/\lambda \sin(\theta_1)} & \cdots & e^{-j2K\pi d/\lambda \sin(\theta_M)} \end{bmatrix} \quad (6)$$

Correlation matrix of N subarry matrix can be as follow

(7)
+

3 Simulation

We use a 12 sensor linear array as spacing of half wavelength. We divide the both arrays into four overlapped subarrays. We get 6 sensors in each subarray of the linear array. We consider two narrow band coherent signals with DOA at 10^o and -10^o. The SNR is 20dB. A toalt of 500 snapshots are taken from the array. We use spatial smooth subarray method as a pre processing scheme for MUSIC. In Fig 1, we illustrate the spatial spectrum obtained by different methods. Fig 1 a shows the result when there are two closely placed signals at -10^o and 10^o. Fig 1 shows a graph to estimate arrival direction by MUSIC method and two arrival directions. It showed DOA estimation an error about 1.3^o in Fig 1. Fig 2 shows a graph to estimate arrival direction by the proposal method. It showed correctly DOA estimation by proposal method in Fig 2.

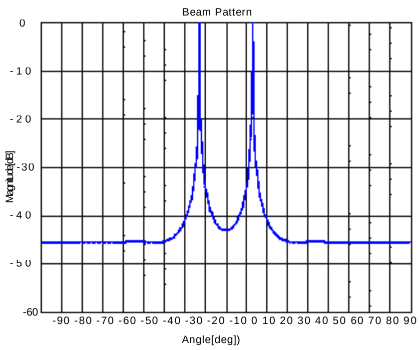

Fig. 1. DOA of MUSIC at -10^o and 10^o

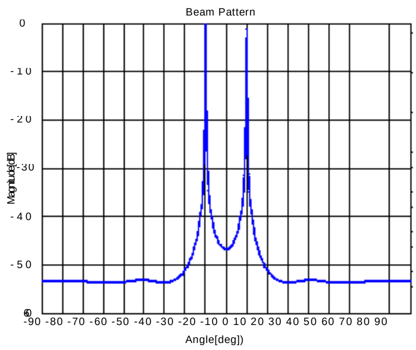

Fig. 2. DOA of proposed at -10^o and 10^o

4 Conclusion

In this paper, we developed DOA methods for applying spatial smoothing using subarray method, thus making MUSIC and adaptive beamformers operative in a coherent interference environment to significantly improve performance robustness in DOA estimation and in adaptive beamforming. We find that we can choose a square array with a sensor spacing less than half wavelength to meet all the conditions required for applying spatial smooth subarry. Simulation results show that for DOA estimation of coherent signals using spatial smooth subarry methods, a s square array has a preferred geometry in terms of the DOA estimation resolution and performance robustness.

References

1. J.E.Hudson.: Adatpive Array Principles, IEE Press, London (1989)
2. EDMOND NICOLAU.: Adaptive Arrays, ELSEVIER Press, NewYork(1983)
3. Jonh Litva.: Digital Beamforming in Wireless Communications. Artech House Press, London(1996)
4. Jingmin Xin, Nanning Zheng and Akira Sano.: Subspace-Based Adaptive Method for Estimating Direction of Arrival with Luenberger Observer. IEEE Transaction on Signal Processing, Vo.59, pp.145--159, IEEE Press, NewYork(2011)
5. Houcem Gazzay.: Optimun Antenna Arrays for Isotropic Direction Finding, IEEE Transactions on Aerospace and Electronic Systems Vo. 47, No. 2, pp.1482--1489, IEEE Press, NewYork(2011)
6. Nanyan Wang, Panajotis Agathoklis and Andreas Antoniou.: A Now DOA Estimation Technique Based on Subarray Beamforming. IEEE Transaction on Signal Processing, Vo.54, No9, pp.3279--3290, IEEE Press, NewYork(2006)