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Performance Analysis of Conventional and Capon Beamformer

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ABSTRACT: Conventional beamformer provides maximum performance under no noise and interferences environment. In the interference and noise signal environment, the performance of this type of beamformer will degrade. Standard capon beamformer will give better performance and signal to interference plus noise ratio (SINR) under interference and noise environment. This beamforming technique suffers from performance degradation under mismatch of the steering vector. In this paper, the comparative study of conventional and capon beamformer is concentrated.

KEYWORDS: SINR,SOI,SNOI

I. INTRODUCTION

Wireless systems receive spatially propagating signals in the presence of noise and interferences. Usually desired signal and interferences occupy the same temporal frequency bands. So temporal filtering cannot be used to separate desired signals from interferences. But they are originating from different spatial locations. This spatial separation can be used for differentiating desired signal from interference signals. Beamformer is a processor in conjunction with array of sensors to provide spatial filtering.

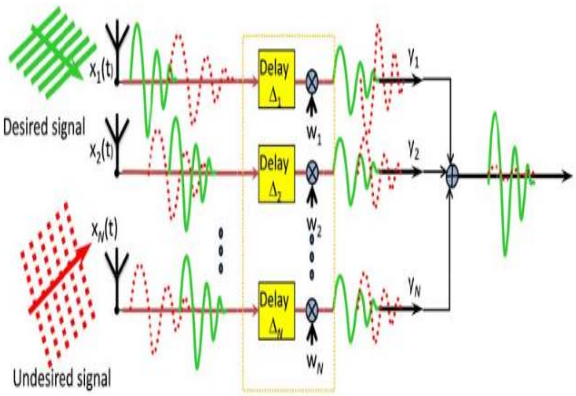

Figure1. Basic Concept of Beamforming

Figure 1 provides the concept of beamforming. Two signals from two different locations are impinging on an antenna array with N elements. These two signals are coming from the far-field region of the antenna array, so the received signals are plane waves. Consider one of them is desired signal and other one is unwanted signal. Since they are coming from different spatial locations, they have different incident angles. The beamformers are designed to assign

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extra delays or phases to the received signal of each antenna so that the desired signal is passed through the beamformer whereas undesired signal is suppressed or attenuated significantly.

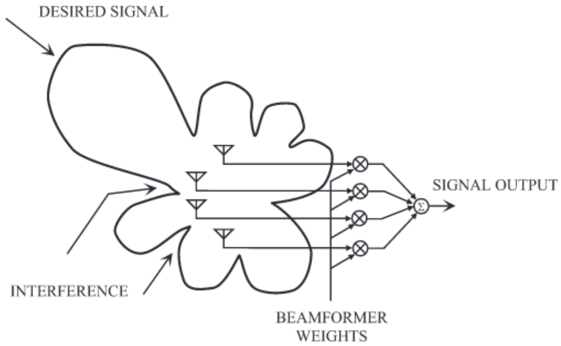

Figure 2. Calculation of the Beamformer Weights

The main objective of the beamforming is to simultaneously place a beam maximum toward the signal-of-interest (SOI) and ideally nulls toward directions of interfering signals or signals-not-of-interest (SNOIs).Figure 2 illustrates the idea of calculating the beampattern weights towards SOI and null towards SNOIs. The beamformer of the array must automatically adjust from the collected information the weight vector $w= [W_1\ W_2\ W_3 \ldots\ W_N]^T$ which correspond to the complex amplitude excitation along each antenna.

II. CONVENTIONAL BEAMFORMER

Beamformers are classified either data independent or statistically optimum beamformers, depending on how the weights are chosen. The weights in the data independent beamformer do not depend on array data and are chosen to present a specified response for all signal and interferences scenario. The weights in statistically optimum beamformers are chosen based on the statistics of the array data to optimize the array response. Conventional beamformers are data independent beamformers.

Conventional beamforming is also called delay and sum method or Bartlett method. In this type of beamformer, the beamforming weights is set to the array response vector of the desired signal.The weight vector adjust the phases of the incoming signal arriving at each antenna element from given direction so that they add in phase (or constructively).Conventional beamformer will give maximum beampattern towards the direction of Signal of Interest (SOI), it lacks the additional ability to place nulls toward any present SNOIs. So SINR will decrease when interference power increases.

III. CAPON BEAMFORMER

Capon beamformer is also called Minimum Variance Distortionless Response (MVDR) beamformer. The conventional beamformer using the weights does not maximize the output SINR. The capon beamforming technique minimizes the total power radiated by the antenna array while the response in a desired direction is maintained and suppress the unwanted noise and interferences. This is a statistically optimum beamforming. In this case, the weight vectors are chosen based on the statistics of the received data. The weights are selected to optimize the beamformer response so that the array output contains minimal contributions due to noise and signals arriving from directions other than that of the desired signal.

The basic idea behind capon beamforming is to constrain the response of the beamformer so signals from the direction of interest are passed with specified gain and phase. The weights are chosen to minimize output variance or power subject to the response constraint. This has the effect of preserving the desired signal while minimizing contributions to the output due to interfering signals and noise arriving from directions other than the direction of Interest The capon beamformer choosing the weights with

$$\min_{w} \quad W^H R_{xx} W \quad \text{subject to} \quad W^H a(\theta)=1$$

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Where Rxx is the signal correlation matrix. a(θ) is the SOI steering vector. w is the beamformer weight vector. The solution to this optimization problem is given by

$$W_{cap} = \frac{Rxx^{-1}a(\theta)}{a(\theta)Rxx^{-1}\,a(\theta)}$$

IV. SIMULATION RESULTS AND ANALYSIS

To understand the working of conventional and capon beamformer, coding is done for these beamformers and plotted the beampattern.

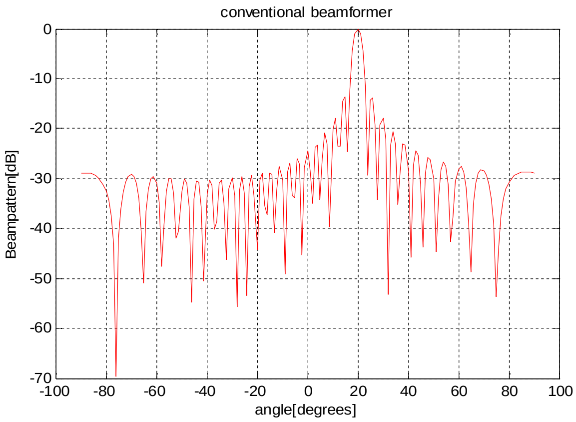

Figure 3: Conventional beamforming

For a uniform linear antenna array,32 number of elements, inter element spacing λ/2,number of samples 181 are considered. Scanning is performed from -90 to 90 degrees. Desired signal direction is taken as 20^0 and interference direction as 60^0.The simulation result of conventional and capon beamformer is shown in figure 3 and figure 4 respectively.

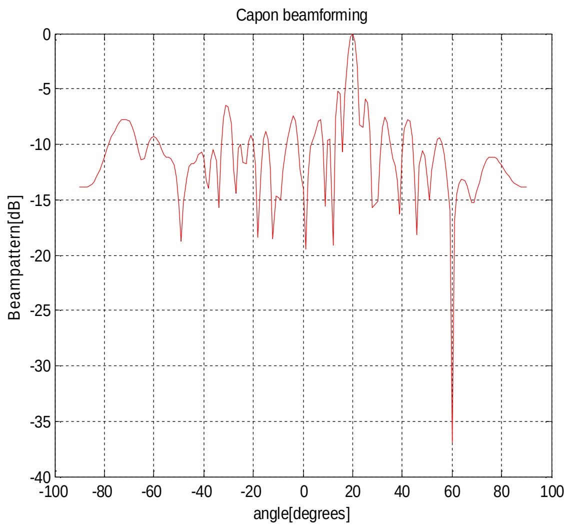

Figure 4. Capon Beamforming

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It is found that Capon beamformer give nulls at interference direction.On the other hand ,conventional delay and sum beamformer cannot cancel the interferences.For this reason, capon beamformer normally prefered for practical applications.

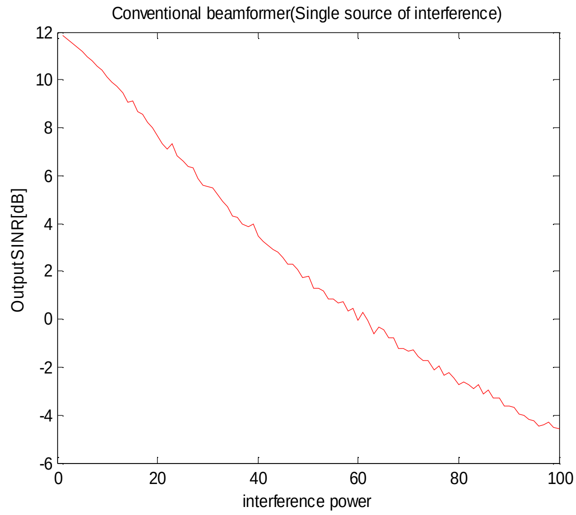

Figure 5:Output SINR Vs Interference Power Plot for Conventional Beamformer with Single Source of Interference

To find out the effect of interferences on conventional and capon beamforming, we have considered a 16 element uniform linear array with half wavelength spacing. Signal's direction is fixed as 10^0 and interference direction is 40^0 for single interference source and signal direction is 10^0 and interference sources directions are 20^0,40^0,50^0, 60^0 and 70^0 for 5 sources of interference.

Table1:Ouput SINR for Conventional Beamformer (Single interference source) of Different Interference Power Level

Interference Power	Output SINR in dB
1	11.8584
10	10.1262
20	7.6629
40	3.4701
60	-0.0642
80	-2.7282
100	-4.5804

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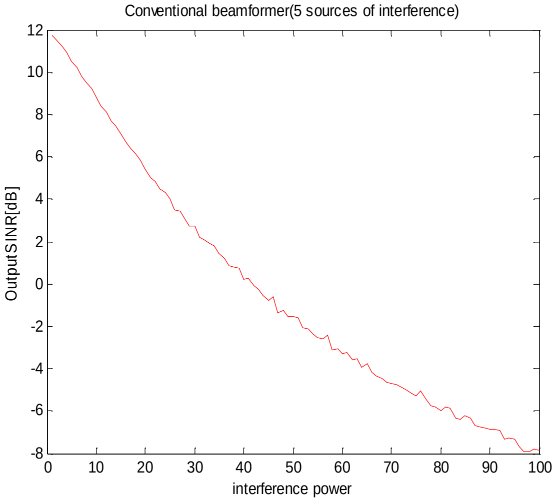

Figure 6. Output SINR Vs Interference Power Plot for Conventional Beamformer with 5 Sources of Interference

Figue 5 and 6 shows the effect of interference on conventional beamforming.it is found that output SINR is decreasing with increasing interference power.

Table2:Ouput SINR for Conventional Beamformer (5 interference sources) of Different Interference Power Level

Interference Power	Output SINR in dB
1	11.7595
10	8.7989
20	5.4156
40	0.2383
60	-3.3168
80	-6.0113
100	-7.8764

Figure 7 and 8 shows the effect of interference on capon beamforming.It is observed that output SINR is almost constant for interference power increases from 0 to 100.And also number of interference sources are not affected the output SINR.

Table3:Ouput SINR for Capon Beamformer (Single interference source) of Different Interference Power Level

Interference Power	Output SINR in dB
1	4.5233
10	4.4683
20	4.3268
40	4.3302
60	4.4009
80	4.3823
100	4.3519

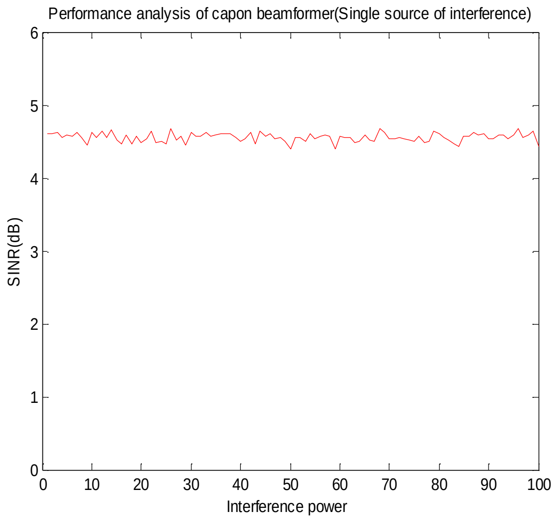

Figure 7. . Output SINR Vs Interference Power Plot for Capon Beamformer with Single Source of Interference

Table4:Ouput SINR for Conventional Beamformer (5 interference sources) of Different Interference Power Level

Interference Power	Output SINR in dB
1	4.5997
10	4.6282
20	4.4755
40	4.4947
60	4.5760
80	4.6010
100	4.4236

Figure 8 . Output SINR Vs Interference Power Plot for Capon Beamformer with 5 Sources of Interference

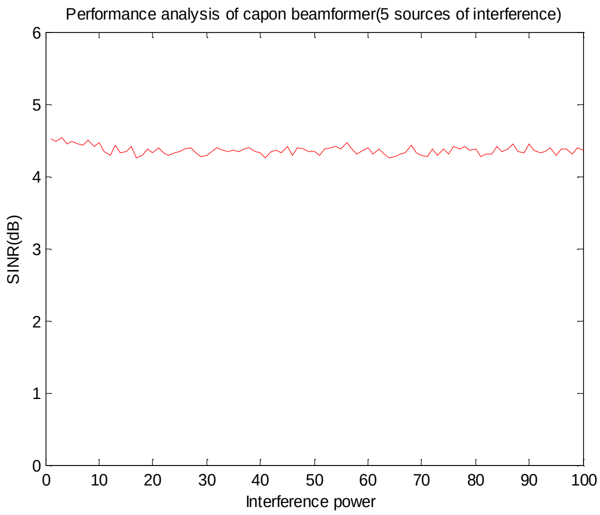

Figure 8 . Output SINR Vs Interference Power plot for Capon Beamformer with 5 sources of Interference

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V.CONCLUSION

In this paper, the radiation pattern of conventional and capon beamforming techniques have been investigated. The dependency of the conventional and capon beamformer output SINR on interference power level is also shown. From these simulation results, concluded that under noise and interference environment capon beamformer works well.

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BIOGRAPHY

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M. Mathurakani has graduated from Alagappa Chettiar College of Engineering and Technology of Madurai University and completed his masters from PSG college of Technology of Madras University. He has worked as a Scientist in Defence Research and development organization (DRDO) in the area of signal processing and embedded system design and implementation. He was honoured with the DRDO Scientist of the year award in 2003.Currently he is a professor in Toc H Institute of Science and Technology, Arakunnam. His area of research interest includes signal processing algorithms, embedded system modelling and synthesis, reusable software architectures and MIMO and OFDM based communication systems.