A New Method to Improve Capon Algorithm

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***Abstract*— Array process is a part of signal process. Here, angular resolution is attended so that, every year some articles are published. The purpose of this article is improving the resolution of capon algorithm for angles close together. So, statistical method is used for algorithm improvement. It is shown that proposed algorithm for angles close together has better results.**

***Index Terms*— beam forming, entry angle, capon algorithm, improving performance.**

I. INTRODUCTION

Since the basis of some beam shaping methods is initial estimates of beam angle , so it is needed before applying techniques , the angle of signal entry is clear . the estimation of incoming waves angle is very important . to estimate entry angle or DOA, many algorithms are proposed such as music algorithm , root music, esprit and capon[1].

In systems which use array antenna , receiver design, processors and antenna array cause optimality of receiver in a specific direction and remove signal beam reached to array from a certain direction or estimate incoming wave to array.

Choosing the type of elements is very important according to array application that is one of the most important task off antenna designer[2] .

The second issue depends on the application of array antenna[3], that is the layout of sensor array used in linear , rectangular and circular layout [4-5].

Generally , array process methods are divided into 3 categories : the first is based on linear systems considered as generalized space-time operation. These methods performs better that linear methods and passes fundamental limits on the performance of linear methods .

The thirds methods are based on information theory presented in the two last decades to solve some issues not resolved by previous insolvable approaches.

In reference [6] , estimation of entry angle with high resolution is examined . in this article , estimation of signal parameter with high resolution as one of the most important issue in signal processing application such as estimation of signal entry angle in narrow band and broad band composed of some submitter source and receive angle is considered . in this reference , we examine modified music algorithm method .

In reference [7] , resolution of signal entry angle is improvable by using antenna and innovative signal process. methods with high resolution use array structure to improve receive signal process with ability to identify multiple targets . In reference [8] , we examine and analyze eigenvalue of algorithms with high resolution. In reference [8] , we examine a new method to estimate entry angle for the above references in which receive antenna is located based on heterogeneous array design .

In this article , capon algorithm is improved based on statistical methods . so , we introduce capon algorithm then, a method is suggested . according to this method , simulations are done and compared with capon algorithm.

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II. CAPON ALGORITHM

To increase ability to estimate entry angle close together more than conventional beam width of antenna , we use capon as following . this method is presented as a classical method to estimate the angle of signal entry . suppose that output array elements are combined by the below weights [9]:

$$\mathbf{w}_k = \exp(-j\omega x_k), \qquad k = 1, 2, ..., N \qquad (1)$$

In this formula , ($\omega = 2\pi \sin(\theta)$) , that (θ) is the direction of antenna and ($x_k = \frac{d(k - \frac{N+1}{2})}{\lambda}$) is the location of array elements on (x) axes measured based on wavelength.

when, (θ) with (θ_0) as source of input signal is coincident , then receive signals compensate receive signals of each other phases and gathered as coherent , so main signal is amplified in direction of (θ_0) . while, unwanted signals are not amplified like noise. Mathematically angular range include received power in direction of ach antenna .

In this method, by select of coefficients , signal array is passed through desired direction. it means that , array coefficients are selected so that signal is passed without any attenuation and the highest attenuation is related to noise and unwanted signals , meaning that noise and unwanted interference signals that cause disorder in specifying the above signal , attenuate it .

As it is clear , the above algorithm is used to determine the direction of signal resources around array . in this method, vector of capon algorithm coefficient (w) is selected to minimize the effect of interference and noise of output power to make the achievement in desired direction θ equal to 1 [10]:

$$\min W^H R_X W \qquad (2)$$

$$\text{s.t} \quad W^H a(\theta) = 1$$

That W is equal with [11]:

$$W_{CAP}(\theta) = \frac{\hat{R}_x^{-1} a(\theta)}{a^H(\theta)\hat{R}_x^{-1} a(\theta)} \quad (3)$$

Now, according to the achieved coefficient vector , output power of system is equal to :

$$P_{CAP}(\theta) = \frac{1}{\mathrm{a}^{\mathrm{H}}(\theta)\hat{\mathrm{R}}_x^{-1}\mathrm{a}(\theta)} \quad (4)$$

To find the direction of receive signal we use the above formula . first , we draw p(θ) based on θ in direction p(θ) with high value , meaning that there is signal .

It is needed to mention that resolution is limited in this method but is more favorable than direct normal radiation. another disadvantage of this method is that unwanted signals in environment must be correlated with desired signals .

In this conditions , unwanted signal may combine together and capon method goes wrong and this method may be failed.

High computational loading of this method in great arrays to find direction and estimation of entry angle of receive signal can be another disadvantage of this method due to inverse matrix calculation .

Another disadvantage of this method compared with direct of normal beam is high sensitivity to gain and phase error[12] .

III. Proposed Method

Capon algorithm presents an optimized algorithm to solve estimation of entry angle . this algorithm maximize the receive power on entry angle variable to achieve the estimation of entry angle .

The performance of this system is weak when angles are close together to separate them and transfer this issue to a space with ∞ dimensions and gain conditions in which probability of data resolution is more and better . So cornel of capon algorithm by one of the best cornel, Gaussian cornel, is:

$$P_{CAP}(\theta) = \frac{1}{\mathrm{a}^{\mathrm{H}}(\theta)\hat{\mathrm{R}}_x^{-1}\mathrm{a}(\theta)} \quad (5)$$

In the above relation , $\mathrm{a}(\theta)$ is the vector of direction as :

$$a(\theta) = \left[1 + e^{j\varphi} \quad \ldots \quad e^{\mathrm{j}(1-1)\varphi}\right] \quad (6)$$

In this relation, $\varphi = -kdcos(\theta) = -\frac{w}{c}dcos(\theta)$, we have θ entry angle and (d) is the intervals between antenna elements . capon algorithm is converted to Dot-product as following :

$$\left(\mathrm{a}^{\mathrm{H}}(\theta)\mathrm{R}_{\mathrm{X}}^{-1}\right)\mathrm{a}(\theta) = \left(\left(R_X^{-1}\right)^H a(\theta)\right)^H a(\theta) \quad (7)$$

Finally, capo algorithm will be kernelized:

$$\mathrm{P}_{CAP}(\theta) = \frac{1}{X^H.Z} = \frac{1}{e^{\frac{\|X-Z\|^2}{2\sigma^2}}} \quad (8)$$

IV. Simulation

In this conditions , both algorithms have a good performance . but with reducing the angle between the two sources , angular resolution signal of capon algorithm is reduced .

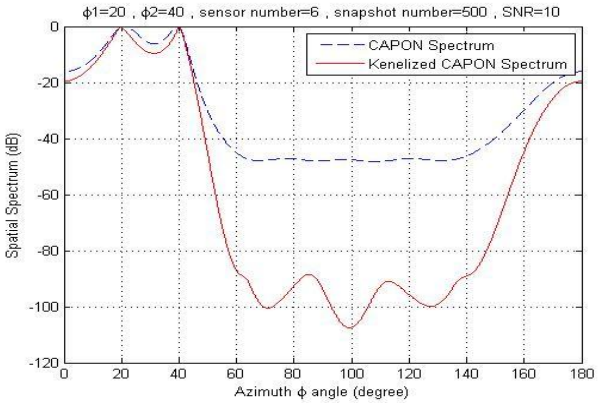

Figure 1 : The estimated angle of 20 ° and 40 °

as figure 2 indicates , when entry angle is 20 and 30 degree, capon algorithm is not able to specify two sources while improved capon algorithm can resolve the entry angle 20 and 30 degree .

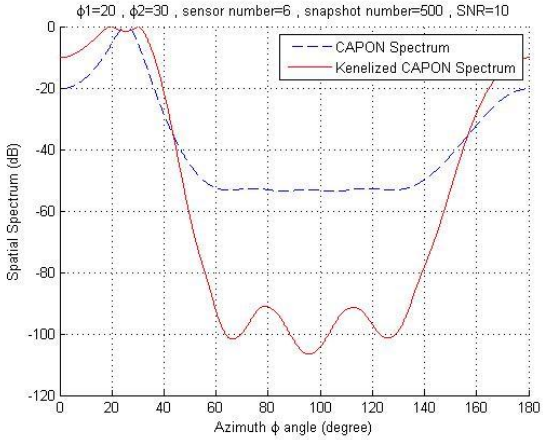

Figure 2 : entry angle 20 and 30 degree

When entry angle is 20 and 25 degree , improved algorithm is not able to resolution.

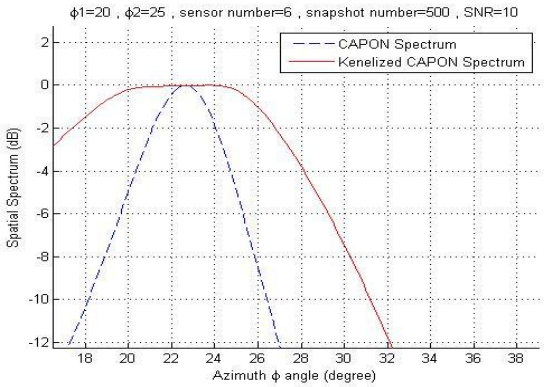

Figure 3: entry angle 20,25 degree

As figures 4,5,6 indicates , with increase of snapshot , number of array or SNR , improved algorithm is able to resolve .

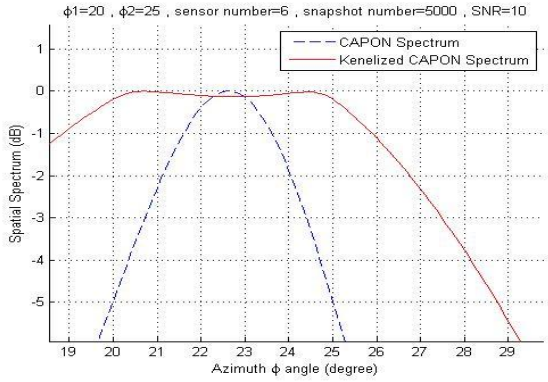

Figure 4 : entry angle 20 and 25 degree with increase of snapshot

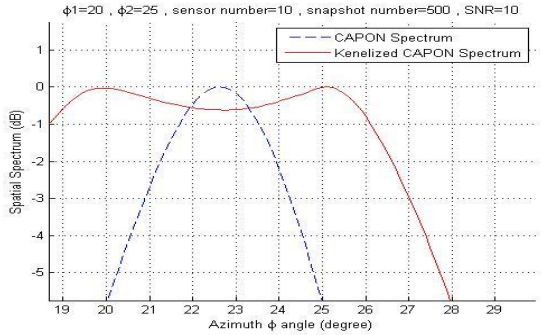

Figure 5 : entry angle 20 and 25 degree with increase of the number of sensors

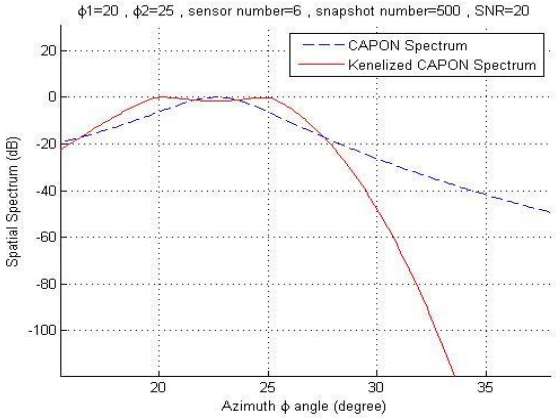

Figure 6 : entry angle 20 and 25 degree with increase of SNR

Despite , capon algorithm is not able to resolve angle. capon algorithm like improved algorithm needs more arrays and SNR to resolve angle 20 and 25 degrees.

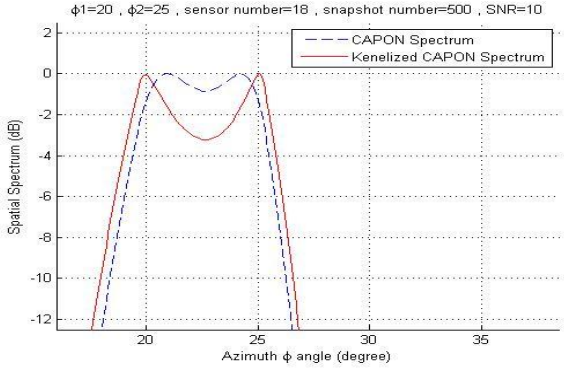

Figure 7 : entry angle 20 and 25 degree with 18 sensors

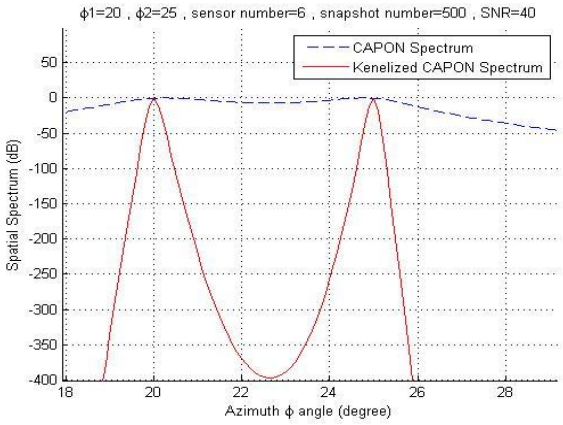

Figure 8 : entry angle 20 and 25 degree with SNR=40

V. Conclusion

In this article , a new method based on kernelizing core of capon algorithm. In high angular intervals, both capon algorithm and proposed method have an identical results .

When the angles of sources are close together , the proposed method acts better and resolve angles, while in capon algorithm is impossible.

If capon algorithm in angles close together has a similar results like proposed algorithm , the number of sensors and signal rate to noise is increase.

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