Smart Intelligent Computing and Communication Technology
V.D. Ambeth Kumar et al. (Eds.)

doi:10.3233/APC210090

Improved Linearly Constrained Minimum Variance Algorithm for 5G Communications System

Kaviya K R[a,1] and Deepa S[b]
[a]*PG Scholar, Dept of ECE, Panimalar Engineering College, Chennai, India*
[b]*Professor, Dept of ECE, Panimalar Engineering College, Chennai, India*

Abstract. Beamforming is a process formulated to produce the radiated beam patterns of the antennas by completely building up the processed signals in the direction of the desired terminals and cancelling beams of interfering signals. Adaptive beamforming is a key technology of smart antenna. The core is to obtain optimum weights of the antenna array by some adaptive beamforming algorithms and finally adjust the main lobe to focus on the arriving direction of the desired signal as well as suppressing the interfering signal. There are several beamforming algorithms that includes Linearly Constrained Minimum Variance (LCMV) algorithm in which Self Nulling Issue is further reduced by adding multiplier to the MCMV algorithm and it is referred as Improved LCMV (IMPLCMV). A Comparative analysis is done for different multipliers and it is found that w=0.15 gives best result with minimum interference of flat response and also self-nulling issues can be reduced.

Keywords. Adaptive Beamforming, improved LCMV, performance, measurement.

1. Introduction

5G wireless technology delivers higher multi- Gbps peak data speeds, low latency, more reliability, massive network capacity, increased availability and a more uniform user experience to more users. MIMO systems require a combination of antenna expansion and complex algorithms. It is multifaceted, but MIMO has been used in wireless communications for a long time, now it is common for both mobile devices and networks to have multiple antennas to enhance connectivity and offer better speed. MIMO algorithms come into play to control, how data maps into antennas and where to focus energy in space. The beamforming or spatial filtering is a signal processing technique used in sensor arrays for directing signal transmission or reception. An adaptive beam former is a system that performs adaptive spatial signal processing with an array of transmitters or receivers. The signals are combined in such a way that, signal strength is increased.

[1] Kaviya K R, PG Scholar , Dept of ECE, Panimalar Engineering College, Chennai;
E- mail: kaviyakr1997@gmail.com

2. Related Works

Orthogonal frequency division multiplexing (OFDM) has been extensively considered as an constructive modulation technique for reducing the effects of inter symbol data rate transmission over wireless links[1]. A new algorithm for downlink multiuser beam-forming in mobile communications is narrated [2]. A hybrid beamforming algorithm utilizing a subset of array elements according to receive signal strength is proposed [3]. Three adaptive beamforming algorithms are proposed that have a prescribed quiescent beam pattern and utilize the remaining degrees of freedom to reduce interference [4]. A new perturbation technique is proposed which enables adaptive beamforming (ABF) in microwave domain using a single-port beam former[5].

3. Structure Description and Analysis

Beamforming or spatial filtering is a signal processing technique used in sensor arrays for directional signal transmission or reception. This is achieved by combining elements in an antenna array in such a way that signals at certain angles experience constructive interference while others experience destructive interference. Beamforming can be used at both the transmitting and receiving ends in order to achieve spatial selectivity. It can be used for radio or sound waves. It has found numerous applications in radar, sonar, seismology, wireless communications, radio astronomy, acoustics and biomedicine. As the name indicates, an adaptive beam former is able to automatically adapt its response to different situations. Some criteria has to be set up, to allow the adaptation to proceed such a way that, total noise output is minimized as shown in Fig1. Because of the variation in noise with frequency, wide band systems may be desirable to carry out the process in the frequency domain. An adaptive beamforming uses different information for updating its beamforming weight to adapt with the situation and perform accordingly.

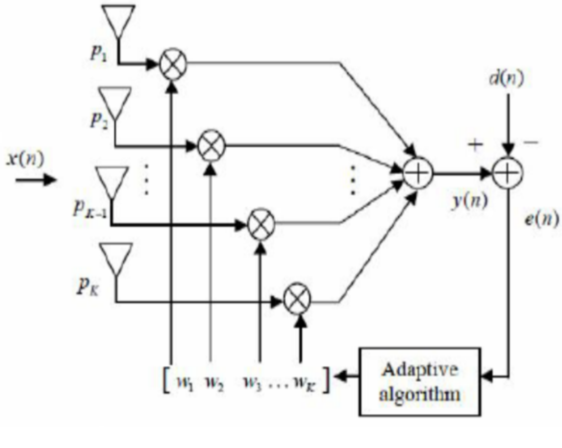

Figure 1. Structure of Adaptive Beamforming

3.1. Smart Antennas

Smart antenna (also known as adaptive array antenna) refers to a system of antenna arrays with smart signal processing algorithms that are used to identify spatial signature such as direction of arrival (DOA) of the signal and it is used to calculate beamforming vectors, to track and locate the antenna beam on the mobile or target. A smart antenna system is an integration between array antenna elements and digital signal processing techniques. An Array signal processing involves the manipulation of signals induced on the elements of an array antenna.

3.2. Phased Array

In antenna theory, a phased array usually means an electronically scanned array, a computer-controlled array of antennas which creates a beam of radio waves that can be electronically steered to point in different directions without moving the antennas. In a simple array antenna, the radio frequency current from the transmitter is fed to the individual antennas with the correct phase relationship so that the radio waves from the separate antennas add together to increase the radiation in a desired direction and to suppress in undesired directions.

4. Linearly Constrained Minimum Variance Algorithm

The majority of designed beamforming algorithms require some knowledge of the reference signal and the strength of the desired signal. These limits can be overcome by applying linear constraints to the weight vector.

5. Proposed Work

In MVDR, self nulling issue is the major disadvantage which is overwhelmed in Linearly Constraint Minimum Variance (LCMV) algorithm. It is further reduced by calculating weights, which is referred as Improved LCMV (Imp LCMV).The comparative study of different weights (w=o.15, 0.35, 0.5, 0.65, 0.8) is analyzed and the best one is selected among them. The weights can be chosen according to the application.

5.1. Improved LCMV

In Improved LCMV, the weights are added which is represented by m to further enhance the self-nulling issues. The Improved LCMV filter generalizes LCMV by reconstructing simultaneously *n* sources sqi, i=1,…,n. Specifically, a (n x 1) vector of source amplitudes s={sq1,…,sqn} is represented as

S(t)=WT b(t) with W being a (M x n) matrix of weight vectors corresponding to each source: W={wq1,…,wqn}. Weights W are selected so as to minimize *total* average reconstructed source power Σi=1n⟨sqi2⟩=⟨|s|2⟩subject to a constraint WTH=In. Here, a (M x n) joint forward solution matrix H={hq1,…,hqn} is defined and In is an n dimensional identity matrix, The minimum power is given by ,

$$W=R^{-1} H (H^T R^{-1} H)^{-1} \qquad (1)$$

Imp LCMV= m LCMV*0.5; hold on; % compare to MVDR pattern(ula,carrierFreq,-180:180,0,'Weights',impLCMV,...'PropagationSpeed', physconst('Light Speed'), 'Normalize', false,... ' Type', 'powerdb ', 'Coordinate System', 'rectangular');

6. Result and Discussion

From the above proposed work, it is seen that the weights (w) can be added increasingly or decreasingly according to our application required. Here, different weights are being analyzed and the least angle is chosen as the best one, due to its less nulling issues. A comparative analysis of IMP LCMV for different weights is shown in Table 1. The data can be stored via edge computing, so that response time can be improved in future work .

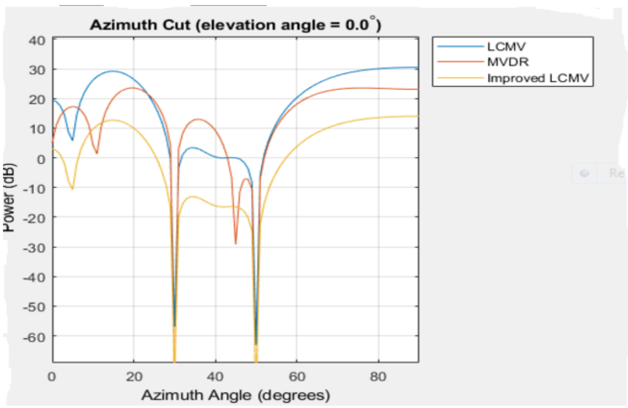

Figure 2. Self Nulling at w=0.15

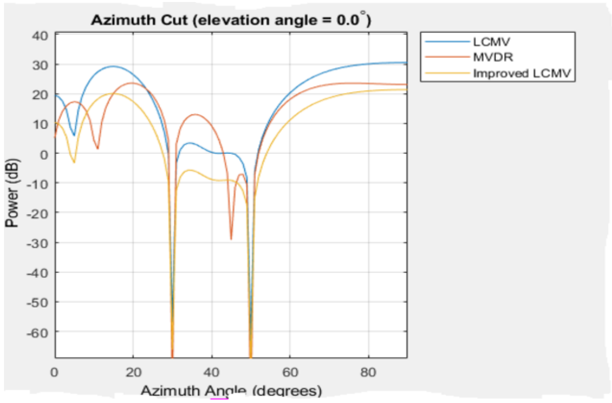

Figure 3. Nulling issue at w= 0.35

Fig. 2 & 3 represents the point at which the nulling issue is reduced so that the interference problems can be minimized. From the above two cases, it is found that case 1 gives best result, because it produces flat response at its low power and also the nulling issue is further reduced.

Table 1. Different X and Y values for different weight

Weights	X	Y
0.15	77	+20.506
0.35	77	+13.147
0.5	78	+23.7596
0.65	78	+26.03
0.8	78	+27.842

Table.1 represents the power and angles for different increasing weights. The analysis shows that w= 0.35 shows the best result because of its low power and also the nulls are reduced.

7. Conclusion

The self nulling issue is overwhelmed in Linearly Constraint Minimum Variance (LCMV). From the analysis, the self nulling issue is further reduced in Improved Linearly Constraint Minimum Variance (Imp LCMV) Algorithm. The self nulling issue is analyzed for five different weights. (weights at w= 0.15, 0.35, 0.5, 0.65, 0.8). It is found that w=0.35 gives the best result when compared to other values. Further, the convergence rate for different SNR can be calculated so that the LCMV will be more suitable for many applications.

References

[1] Ya-Han Pan and Khaled Ben Letaief ,Dynamic Spatial Sub channel Allocation With Adaptive Beamforming for MIMO/OFDM Systems, IEEE Transactions On Wireless Communications, VOL. 3, NO. 6, November2004.

[2] Nanyan Wang, PanajotisAgathoklis, and Andreas Antoniou .A Subspace Multiuser Beamforming Algorithm for the Downlink in Mobile Communications. IEEE Transactions On Circuits And Systems—II: express briefs, VOL. 53, No. 8, August2006

[3] Ya-Han Pan and Khaled Ben Letaief . Dynamic Spatial Sub channel Allocation With Adaptive Beamforming for MIMO/OFDM Systems. IEEE Transactions On Wireless Communications, VOL. 3, NO. 6, November2004

[4] Nanyan Wang, Panajotis Agathoklis, and Andreas Antoniou .A Subspace Multiuser Beamforming Algorithm for the Downlink in Mobile Communications. IEEE Transactions on Circuits and Systems—II: express briefs, VOL. 53, No. 8, August2006

[5] Nuri Celik, Wayne Kim, Mehmet F. Demirkol, Magdy F. Iskander, Rudy Emrick ,Implementation and Experimental Verification of Hybrid Smart- Antenna Beamforming Algorithm, IEEE Antennas And Wireless Propagation Letters, VOL. 5,2006

[6] Spyridon Vassilaras and George C. Alexandropoulos. Cooperative Beamforming Techniques for Energy Efficient IoT Wireless Communication. 2017 IEEE International Conference on Communications (ICC), May 2017

[7] Maheshwari, M. K., Agiwal, M., Saxena, N., & Roy, A. (2017). Flexible Beamforming in 5G Wireless for Internet of Things. IETE Technical Review, 1–14

[8] K.R Kaviya and Deepa S .An Inclusive Survey on Various Adaptive Beamforming Algorithms for 5G Communication Systems Journal[IOS-Press], Scopus, doi:10.3233/APC2001.