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Research Article

5G VANETs: A Details Performance Analysis of Fusion Beam Forming Techniques for Vehicular Environment

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Abstract: VANETs place an important role in an intelligent transportation system. The main aim is to exchange traffic information to avoid accidents and provide proper communication between the vehicles. A great challenge for VANETs is managing of high mobility and fast changes in the topology. VANETs suffer from the problem of undesired signals. Various mechanisms have been proposed for undesirable signals. But all these methods are having problems like high signaling, slow convergence rate, and computational complexity, etc., This technique is proposed for 5G VANETs using fusion Beam forming Algorithms and this is an optimum technique between simple and complex techniques. We have designed and implemented the novel method using MATLAB simulation and outcomes show that our method gives more accurate values of the location of mobile vehicles, and precise cancellation of interference signals compared to other existing methods, and we have tested the implemented simulation program with some known speech signals.

Keywords: VANETs, LMS, SMI, CMA, RLS, MMSE, LSCMA, DLSCMA.

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1. Introduction

Day by day, as a great extent of increasing vehicles, traffic plays an important role in the road transportation system. To control the traffic system, VANETs plays an important role. Vehicular ad hoc networks (VANETs) use roadside units' infrastructure and vehicles equipped with on-board units for exchanging the traffic information [1]. Vehicles use various technologies like vehicle to vehicle and vehicle to infrastructure communication based on cellular networks, Wi-Fi, and ZigBee, and dedicated short-range communication [2]. Communication between vehicles plays an important thing in VANETs. Mobility model and channel models basically use for connecting a vehicle in VANETs.

Figure 1. Architecture

V2V technology will help us to reduce accidents and also congestion among vehicles. At present wide beam, omnidirectional antennas are using for gaining performance [3]. But due to the high extent mobility of vehicles and long-distance of vehicles performance is degrading [4]. To solve this problem, this paper proposed a hybrid beamforming technique to achieve high gain and reduce the interference problems of undesired signals [5].

The rest of this paper is organized as follows: in Section 2 we discuss related work, in Section 3 we state the Explain Various beam forming techniques, in Section 4 we implemented proposed hybrid method, in Section 5 we designed the MATLAB simulation and results, and in Section 6 we conclude the paper.

2. Related Work

Experiments and analytical studies have been conducted for finding the mobility of vehicles in VANETs. For increasing the performance of mobile vehicle broadband, Long term evolution place a promising technology. The main problem with LTE is cell-edge user coverage and also a low data rate in it [7]. This is because of the inter cell interference problems. To characterize the distance between vehicles on the highway proposed a model called Gaussian – exponential mixture. To coordinate the multipoint transmission in a multicell system using the Grassmannian beamforming technique. The best approach for improving the performance at the cell edge is a coordinated multipoint, but it suffers from high signaling [19]. For low power consumption, LMS places an important role, but having a low convergence rate. The recursive least square method is implemented for a time-varying environment, but it's having problems due to high computational complications [6].

The fixed beamforming approaches mentioned are included the MSIR, the ML method, and the MV method were supposed to apply for fixed arrival angle emitters. the ideal array weights won't need to be adjusted, If the arrival angles don't variation with time, [13][14][15]. However, if the wanted arrival angles vary with time, it is required to devise an optimization scheme that operates *on-the-fly* to keep recalculating the optimum array weights. It must allow for the continuous adaptation to an ever-changing electromagnetic environment The receiver signal processing algorithm [8]. For the calculation of continuously updated weights the adaptive algorithm takes the fixed beamforming process one step further and allows. a specified optimization criterion must satisfy the adaptation process. Several examples of Best optimization techniques are *Constant Modulus Algorithm* (CMA), LMS, *conjugate gradient,* SMI, *Recursive Least Squares* (RLS),*,* and waveform diverse algorithms [9][10]11][12][16][17][18].

An alternative means for optimizing the array weights are found by minimizing the MSE. The modified in such a way as to minimize the error while iterating the array weights. The modified array configuration with sample example LMS is shown in Figure 1(a).

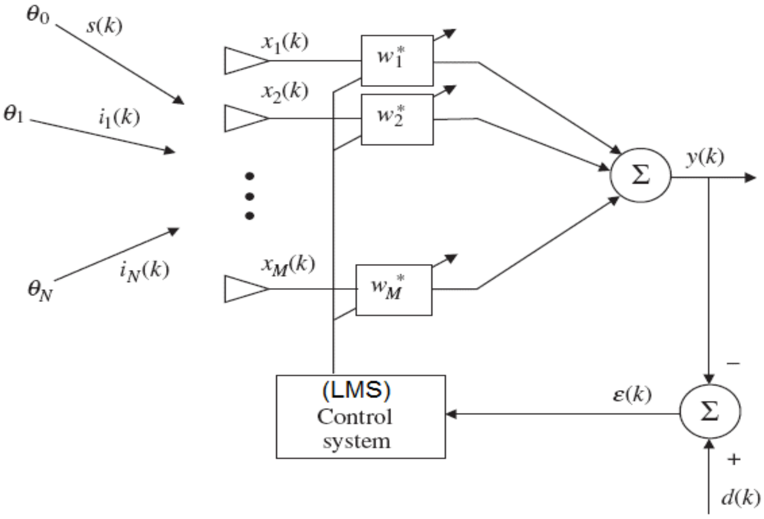

Figure 1(a). Adaptive Beam Forming Technique

The signal $d(k)$ is the reference signal. Preferably the reference signals either identical to the desired signal $s(k)$ or it is highly correlated with $s(k)$ and uncorrelated with the interfering signals $i_n(k)$. If $s(k)$ is not distinctly different from the interfering signals, the minimum mean square technique will not work properly. The signal $\varepsilon(k)$ is the error signal such that

$$\varepsilon(k) = d(k) - \bar{w}^H \bar{x}(k) \tag{1}$$

We can establish the performance surface (cost function) by again finding the MSE as the weights also changing with respect to time 'k'. The error, as indicated in Figure 5, is

$$\varepsilon(k) = d(k) - \bar{w}^H(k)\bar{x}(k) \tag{2}$$

The squared error is given as

$$|\varepsilon(k)|^2 = |\, d(k) - \bar{w}^H(k)\bar{x}(k)|^2 \tag{3}$$

Momentarily, we will suppress the time dependence for writing the equation in a simple manner. The cost function is given as

$$J(\overline{w}) = D - 2\,\overline{w}^{H}\overline{r} + \overline{w}^{H}\overline{R}_{xx}\overline{w} \qquad (4)$$

Where

$$\overline{R}_{xx} = \overline{x}.\overline{x}^{H}$$
$$\overline{r} = d^{*}.\overline{x}$$
$$D = |d|^{2}$$

3. Adaptive Algorithms

1. Lest Mean Squares (LMS)

LMS is one of the popular adaptive beamforming algorithm. It is based on the principle of gradient based approach. Best way to minimum the shape of elliptic paraboloid is through the gradient method.

Error indication is,

$$e(i) = d(i) - [\overline{w}^{H}(i)\overline{x}(i)] \qquad (4)$$

Squared error is,

$$|e(i)|^{2} = |\,d(i) - [\overline{w}^{H}(i)\overline{x}(i)]|^{2} \qquad (5)$$

Cost function is,

$$C(w) = D - 2\,w_{r}^{-H} + w^{-H}R_{x}\,w \qquad (6)$$

Where, $D = E[|d|^{2}]$

LMS solution is,

$$w(i+1) = w(i) - \mu\,[R_{x}\,w - r] \quad (7)$$
$$= w(i) - \mu\, e(i)\, x(i)$$

The drawback with LMS is found that it needs many iterations before achieving a satisfactory convergence. Tracking the desired signal is difficult if signal characteristics are rapidly changing.

2. Sample Matrix Inversion

Sample matrix is a time average estimate of array correlation matrix using K-time samples. If the random process is ergodic in the correlation, the time average estimate will equal the actual correction matrix.

Estimation of array correlation matrix is,

$$R_{xx}(i) = 1/K\; x_{k}(i)\; x_{k}^{H}(i) \qquad (8)$$

Desired signal by,

$$d(i) = [d(1+ik)\; d(2+ik)\; \ldots\ldots d(k+ik)] \qquad (9)$$

SMI weights can then be calculated as,

$$S_{smi}(i) = R_{xx}^{-1}(i)r(i)$$
$$= [X_{k}(i)\; X_{k}^{H}\,[i]^{-1}\; d^{*}(i)\; X_{k}(i)\,] \qquad (10)$$

however, SMI is faster than LMS, potential originalities and computational problem can reason problems.

3. Recursive Least Squares

RLS iteratively calculates the required correlation vector and required correlation matrix. It performs extremely fast convergence; However, this benefit comes at the cost of high computational complexity.

Thus,

$$R_{xx}(i) = \sum_{j=1}^{i} \alpha^{\,i-j}\, x(j)x^{-H}(j) \qquad (11)$$
$$r(i) = \sum_{j=1}^{i} \alpha^{\,i-j}\, d^{*}(j)\, x(j)$$

α is forgetting factor.

Correlation matrix to start recursion relationship is.

$$R_{xx}(i) = \alpha\, R_{xx}(i-1) + x(i)x^{-H}(i) \qquad (12)$$

From above equation, desire signal is

$$w(i) = w(i-1) + g(i)\,[d^{*}(i) - x^{-H}(i)\, w(i-1)] \qquad (13)$$

Recursive equation allows for easy updates of inverse of correlation matrix.

4. Constant Module Algorithm (CMA)

A constant module can be known that if arriving signals of interest should have a constant module, we can devise an algorithm that restore (or) equalize the amplitude of original signal. It is a famous equalizer algorithm.

Recursive relationship is,

$$w(i+1) = w(i) + \mu \left(1- 1/|y(i)|\right) y^{*}(i)x(i) \qquad (14)$$

Error signal is,

$$e(i) = y(i) \left[1- |y(i)|^{2} \right] \qquad (15)$$

CMA has no convergence problems at all, it does take longer equalizer for right results.

5. Least Square Constant Modulus (LSCMA)

LSCMA is working based on Least square Minimization. In this Method of least squares, one defines a cost function which is weighted sum of error squares. It should note that with better than CMA algorithms, LS-CMA algorithm do better job in nullifying the multipath terms.

Weight vector is given by,

$$u(i+1) = u(i) - \left[j(u(i))j^{H}(u(i))\right]^{-1} \qquad (16)$$

Error is,

$$e(u) = X\, Y_{cm} \qquad (17)$$

$$X = [x(1)\ x(2)\ \ldots\ldots x(i)]$$

$$Y_{cm} = \begin{bmatrix} r^{*}(1)/|r(1)| & 0 & 0 \\ 0 & r^{*}(2)/|r(2)| & 0 \\ 0 & 0 & r^{*}(i)/|r(i)| \end{bmatrix}$$

It is well to update the data blocks for each repetition to maintain up to date adaption on dynamic signal situations, LS-CMA is that it can convergence up to 110 times quicker than conventional CMA algorithm.

6. Dynamic LS-CMA

Since LS-CMA algorithm computed the weights simply based upon fixed block of sampled data. Thus, Dynamic LS-CMA is more appropriate.

Thus, dynamic LS-CMA is,

Array correlation is,

$$R_{xx}(i) = X(i)\, X^{H}(i) / K \qquad (18)$$

Correlation vector is,

$$C_{xr}(i) = X(i)\, r^{H}(i) / K \qquad (19)$$

7. Conjugate Gradient Method

The problematic with steepest descent method has been the sensitivity of union rates to eigenvalue feast of association matrix. It results slower convergences. This can accelerate by CGM. The goal of CGM is iteratively search for optimum solution by perpendicular paths for each new iteration.

CGM quadratic cost function is

$$J(i) = \tfrac{1}{2}\, i^{H}{}_{A}{}^{i} - d^{H}\, i \qquad (20)$$

$$\text{Where, } A = \begin{bmatrix} x_1(1) & x_2(1) & x_M(1) \\ x_1(2) & x_2(2) & x_M(2) \\ x_1(K) & x_2(K) & x_M(K) \end{bmatrix}$$

K is no of snapshots

M is No of array elements
i is unknown weights
d is desired signal

4. Proposed Method

We encouraged from all above beam forming techniques and methods and so our proposed hybrid beam forming method overcomes the drawbacks of above beam forming techniques. The interference signals in the wireless mobile channel coming to the receiver varies with respect to time and location of the receivers and also the number of interferers and their location. When the AOA of interference signals is going to be constant, the interference cancellation is simpler than when the interference scenario is varying with respect to time. Both BSs and MSs using ULA (Uniform Linear Array Antenna) and they are able to do all functions on their own without any other assistance. For example, the MSs can do all functions without the assistance of BSs in finding their location. We implement this research work as follows:

(i) We estimate first the location of MSs by using Three Base Station Antennas Method (based on RSS (Received Signal Strength)).
(ii) By knowing the locations of RSUs and Vehicles, we find the angle of arrival of signals and interference signals if the location of interferers and RSUs are known and verified using AOA- Minnorm-Root & MUSIC method.
(iii) Using ULA antenna, for static interference environment, we use Godara & MVDR methods.
(iv) Using ULA antenna, for dynamic interference environment, we use LMS & RLS Method – Complex Method (Adaptive Beam Forming Techniques).
(v) Finally we develop the hybrid beam forming technique by combining both fixed and adaptive beam forming techniques by studying the time varying nature of the wireless channels, i.e., the angle of arrival of interference signals which may be constant w.r.t. time (static) or varying w.r.t. time (dynamic) as the Vechicles is moving in a particular cell controlled by a RSUs.

Thus the proposed work is an optimum in performance, time saving in the beam forming and efficient and intelligent compared to other beam forming techniques.

5. Simulations & Results

We designed and implemented proposed work of Hybrid Beamforming Technique for vehicular environment using MATLAB 2017 software.

A. MMSE

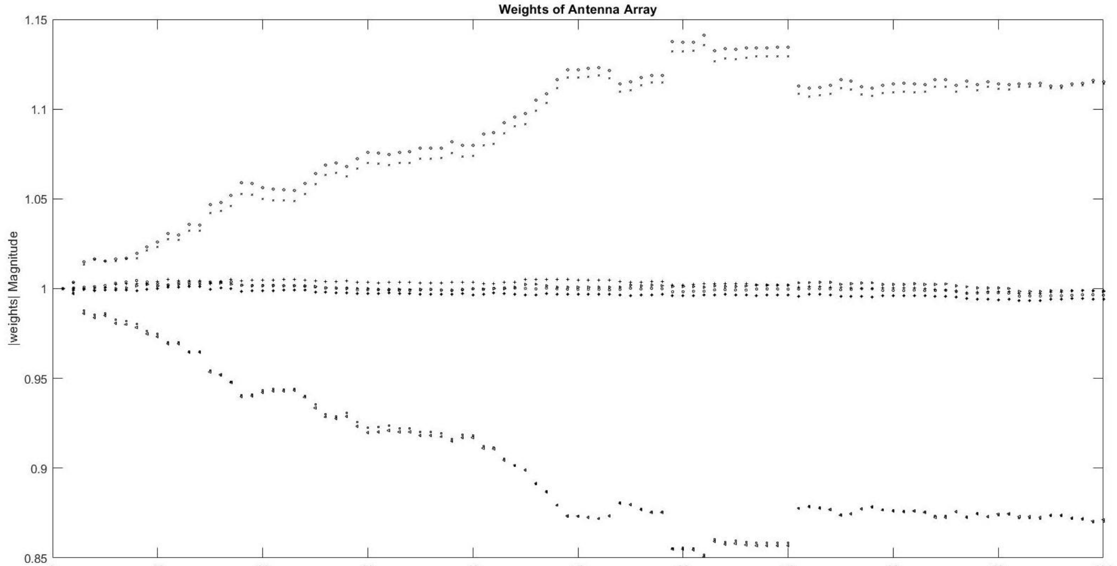

Figure 2. Array Weights of Magnitude (MMSE)

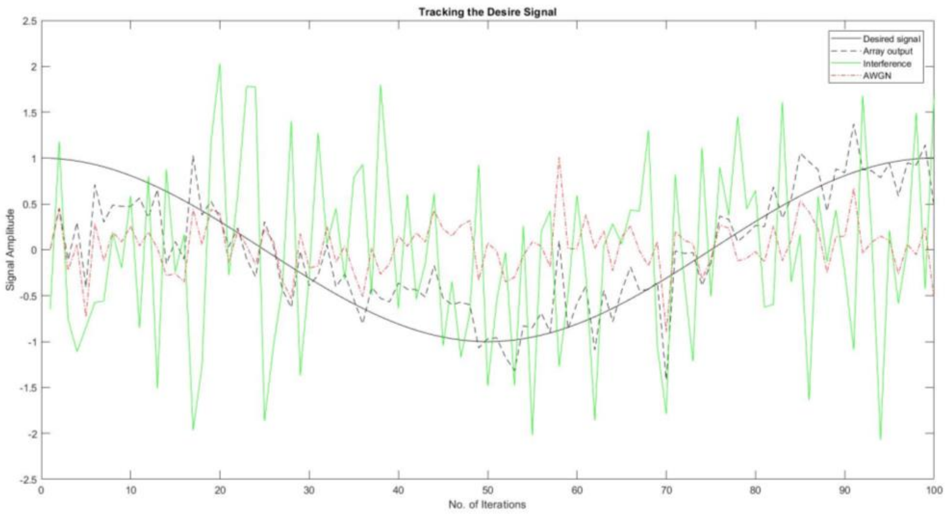

Figure 3. Trailing the Desire Signal (MMSE)

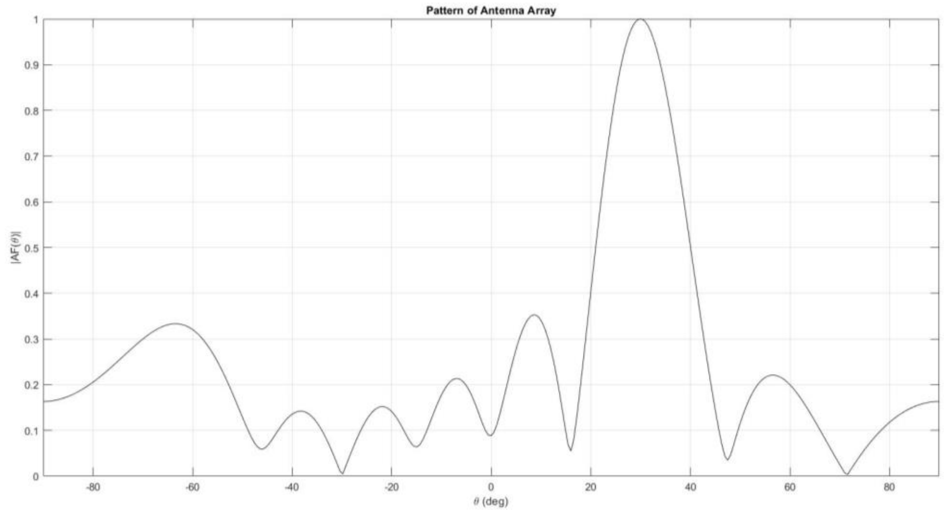

Figure 4. Pattern of MMSE Array

B. CGM

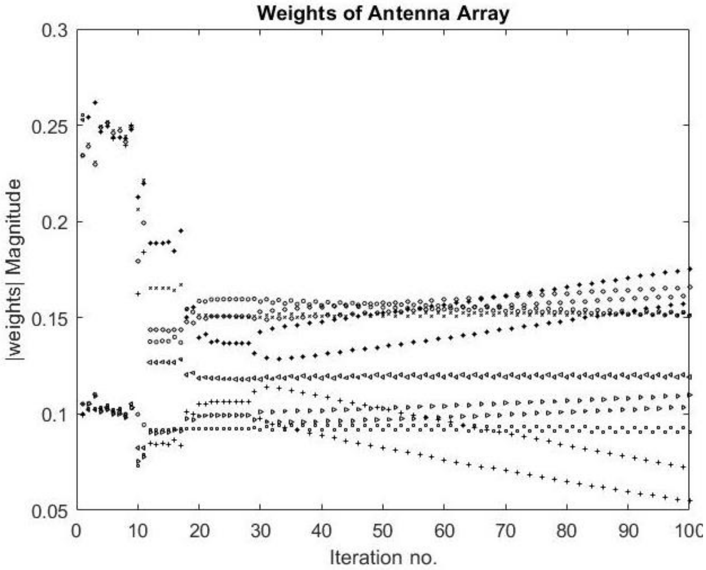

Figure 5. Magnitude of Array Weights (CGM)

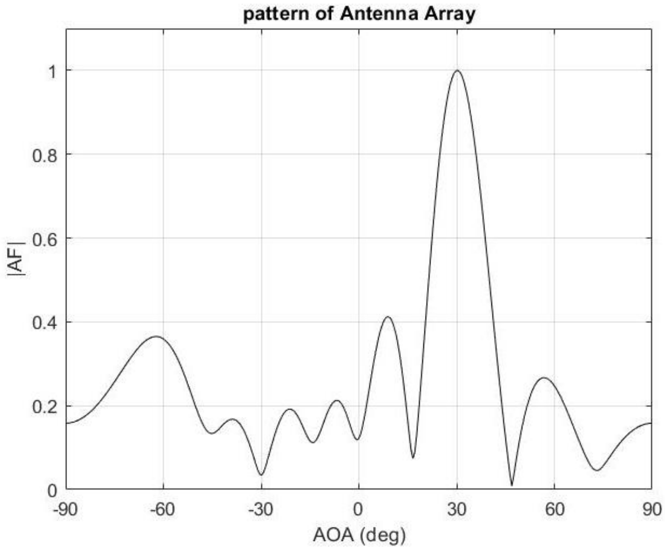

Figure 6. Pattern of CGM Array

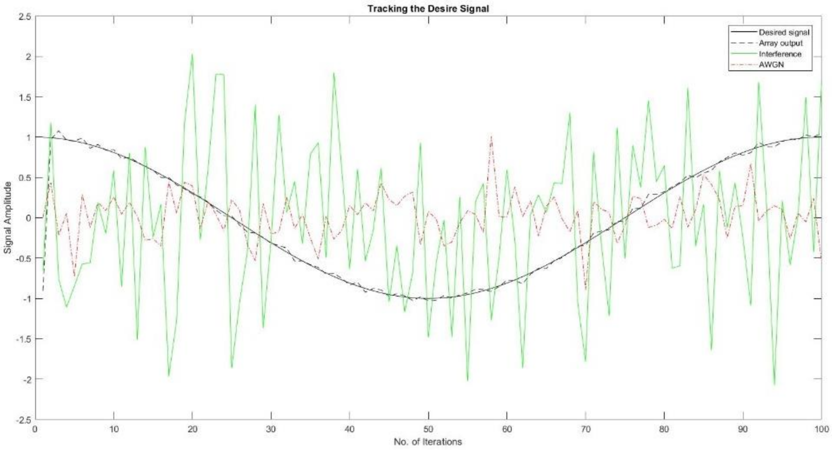

Figure 7. Tracking the Desire Signal (CGM)

C. LMS

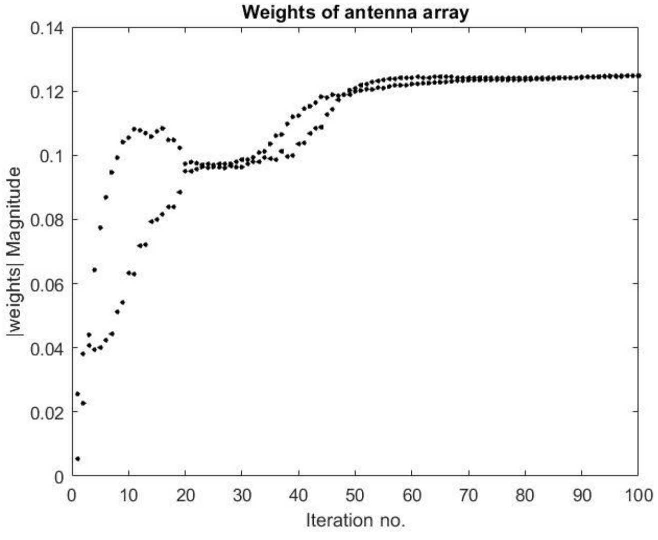

Figure 8. Magnitude of Array Weights (LMS)

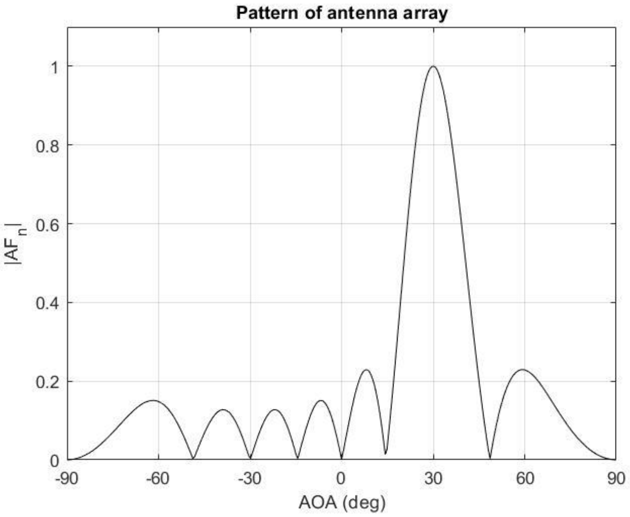

Figure 9. Pattern of LMS Array

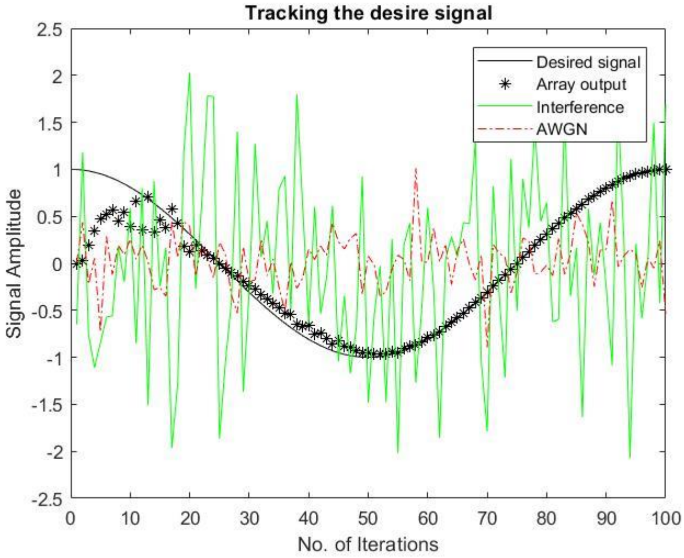

Figure 10. Tracking the Desire Signal (LMS)

D. SMI

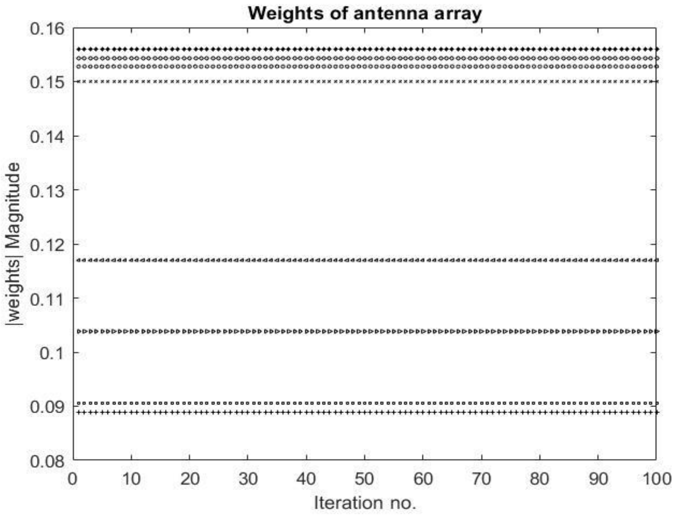

Figure 11. Magnitude of Array Weights (SMI)

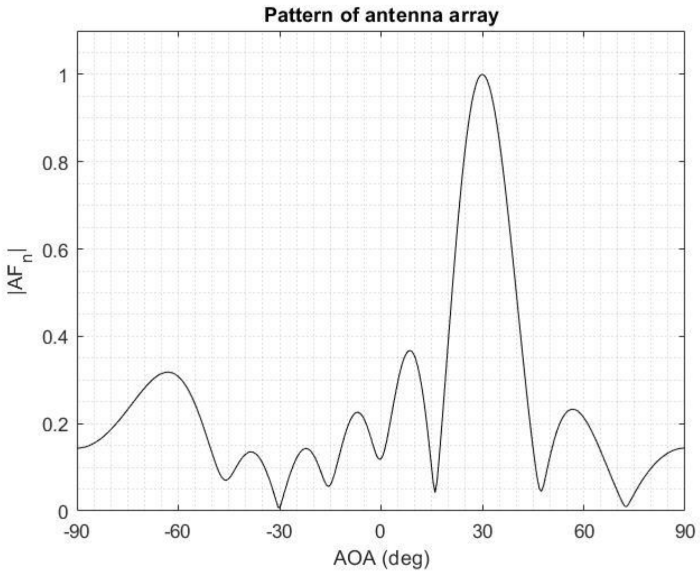

Figure 12. Pattern of SMI Array

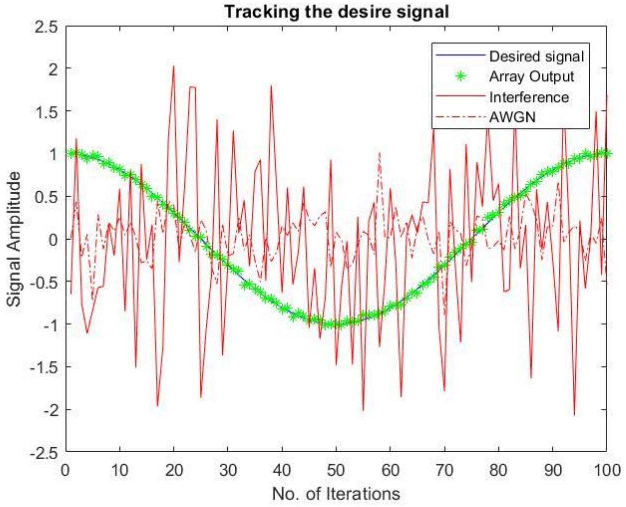

Figure 13. Tracking the Desire Signal (SMI)

E. RLS

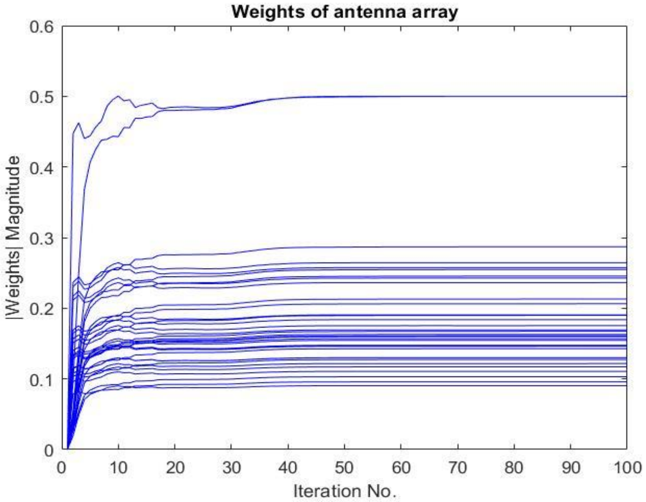

Figure 14. Magnitude of Array Weights (RLS)

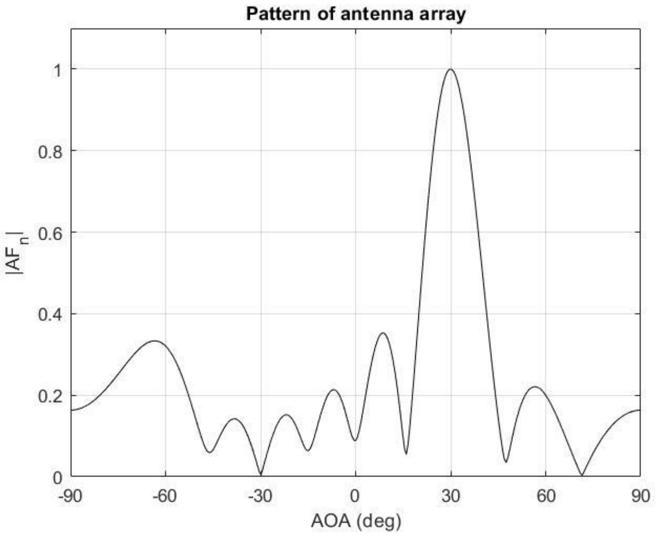

Figure 15. Pattern of RLS Array

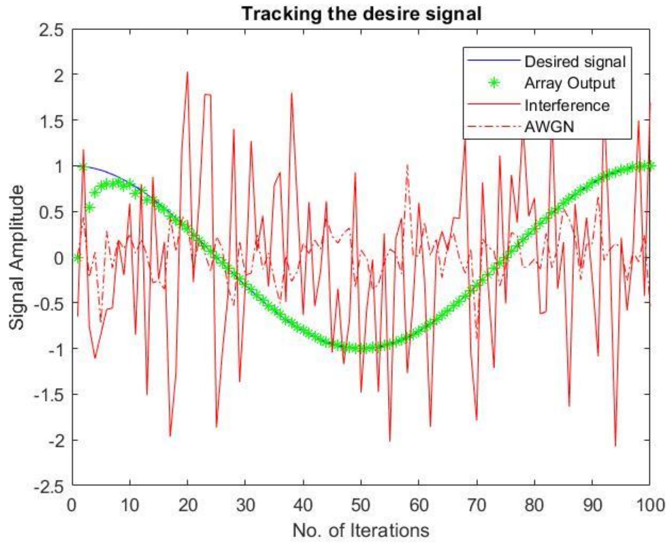

Figure 16. Tracking the Desire Signal (RLS)

F. CMA

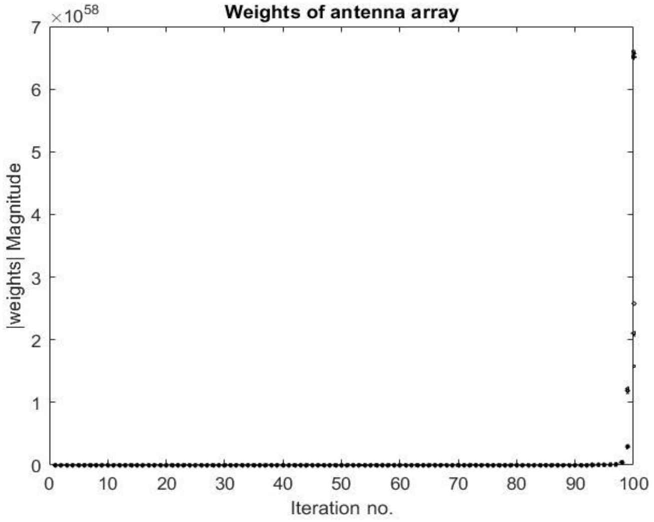

Figure 17. Magnitude of Array Weights (CMA)

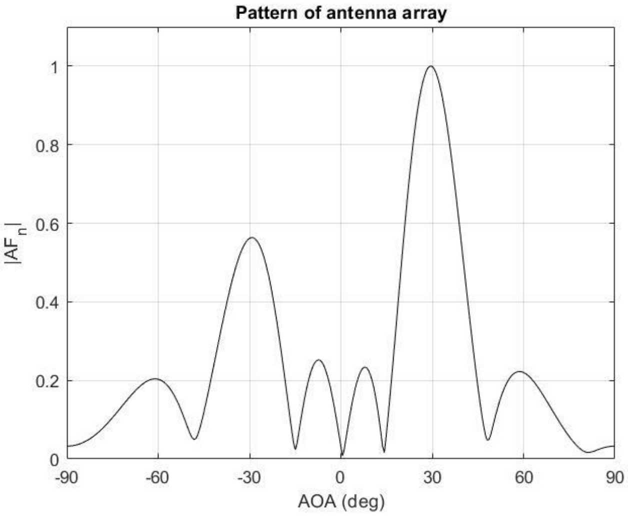

Figure 18. Pattern of CMA Array

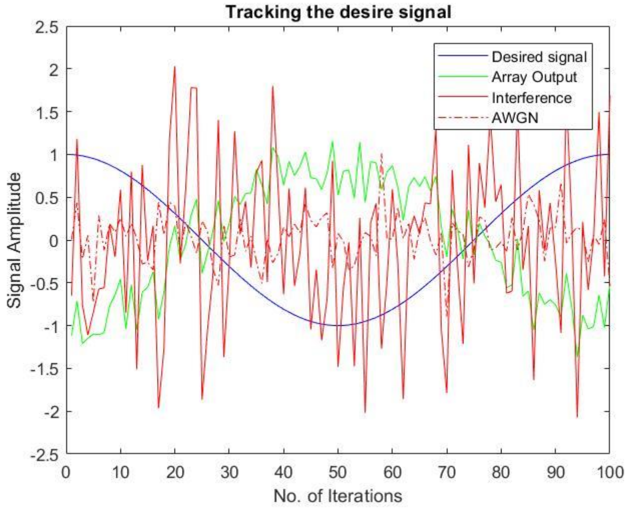

Figure 19. Tracking the Desire Signal (CMA)

G. LSCMA

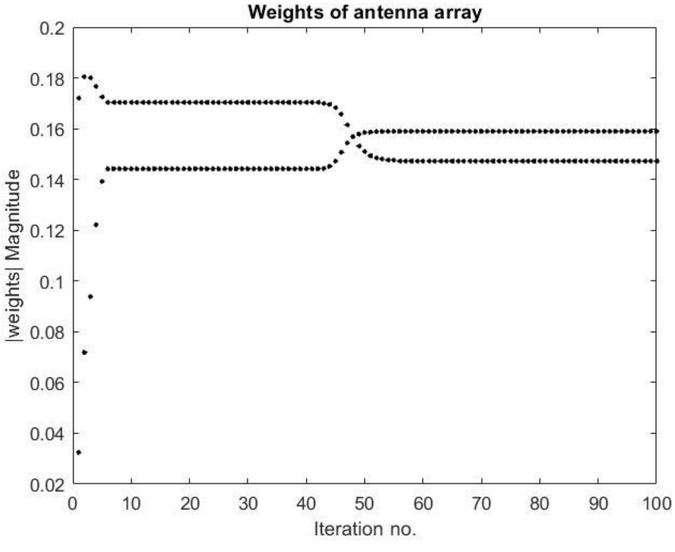

Figure 20. Magnitude of Array Weights (LSCMA)

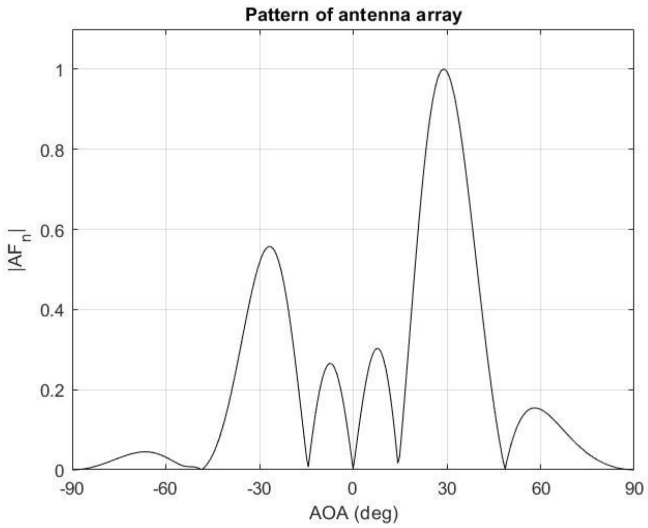

Figure 21. Pattern of LSCMA Array

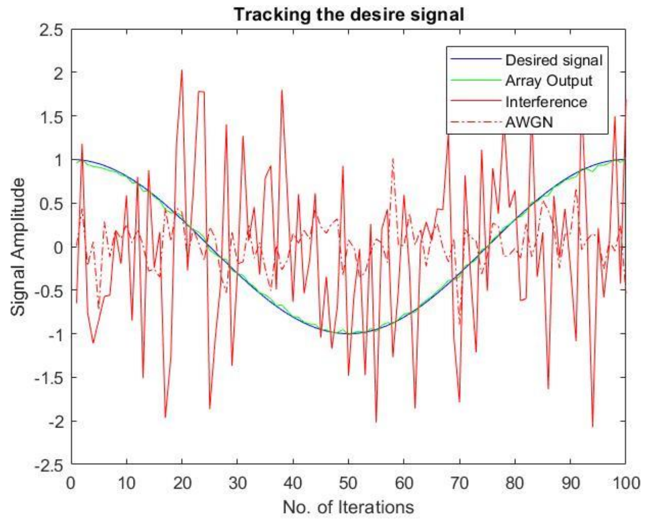

Figure 22. Tracking the Desire Signal (LSCMA)

H. DLSCMA

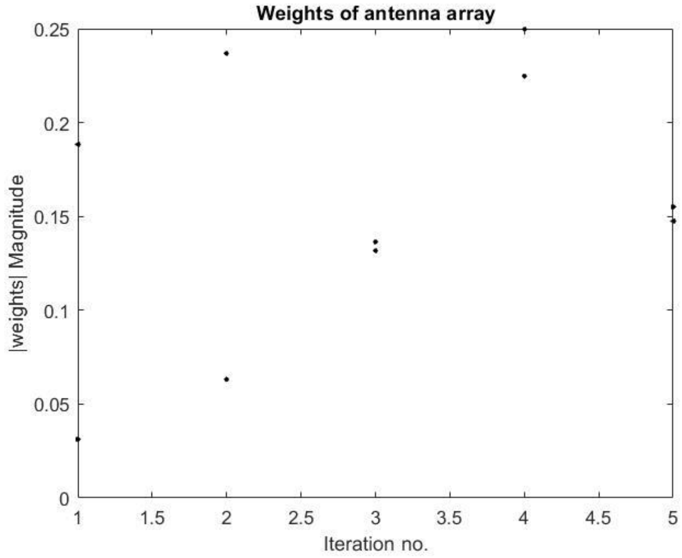

Figure 23. Magnitude of Array Weights (DLSCMA)

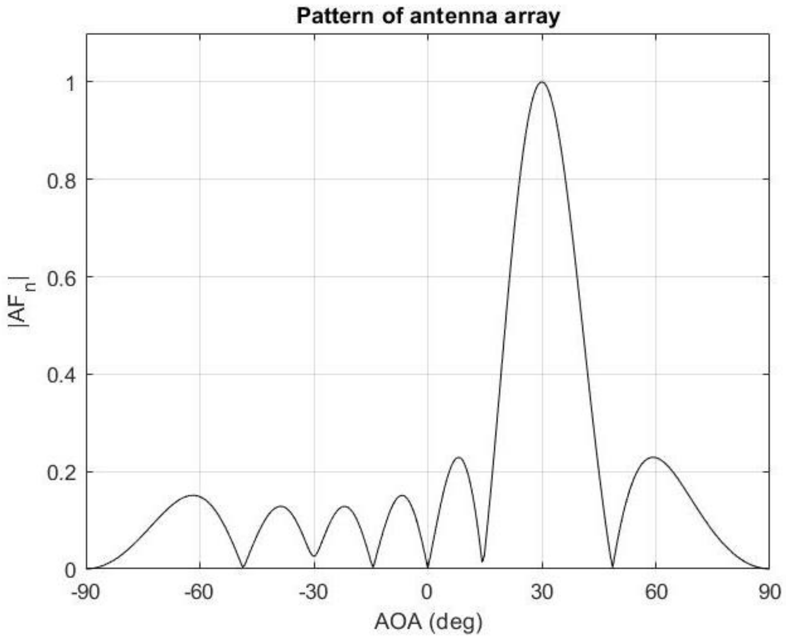

Figure 24. Pattern of DLSCMA Array

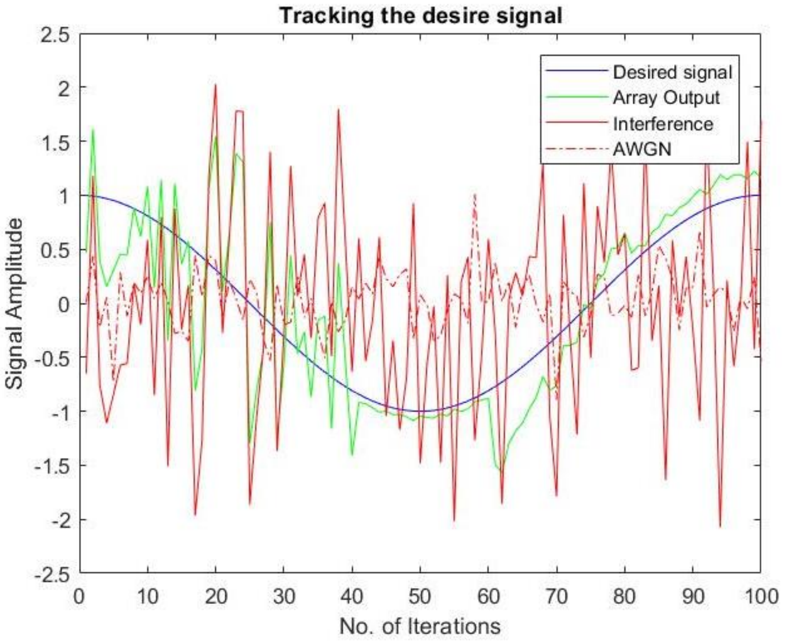

Figure 25. Tracking the Desire Signal (DLSCMA)

Table 1. Various Adaptive beam techniques SIR Table comparison

S.NO	**Techniques/ No of Antennas**	**SIR in dB**						
		TM=2	**TM=3**	**TM=4**	**TM=5**	**TM=6**	**TM=7**	**TM=8**
1	No Beamforming	-0.05	-0.20	2.95	0.19	-0.05	-0.40	2.95
2	MMSE	6.35	5.35	17.12	15.51	13.29	10.92	11.48
3	CGM	22.03	24.07	24.90	23.45	24.15	11.47	22.44
4	LMS	24.17	19.92	24.17	25.15	24.17	27.74	24.17
5	SMI	22.03	24.00	25.33	23.45	24.15	25.54	22.42
6	RLS	24.18	38.32	25.38	35.41	24.39	25.80	22.57
7	CMA	4.63	4.30	4.14	9.86	1.60	3.33	2.98
8	LSCMA	2.75	2.81	2.77	2.82	2.78	2.83	2.78
9	Dynamic_LSCMA	15.92	16.16	15.90	16.01	15.89	15.97	15.89

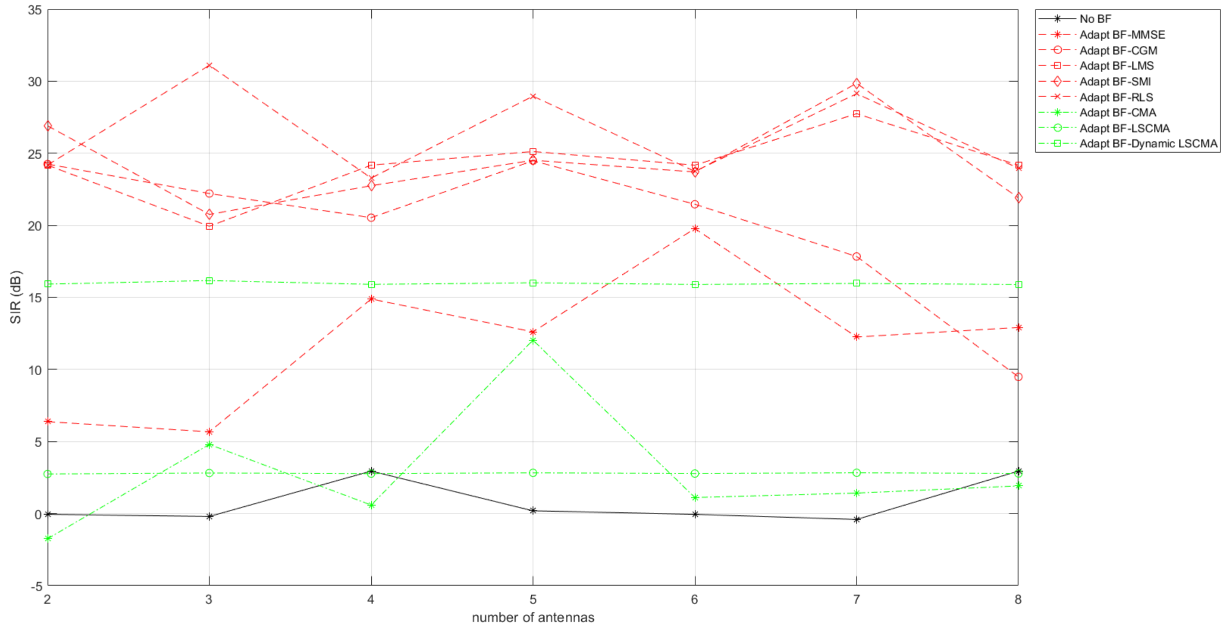

Figure 26. A Comparative analysis of Adaptive beam forming Techniques in VANETs

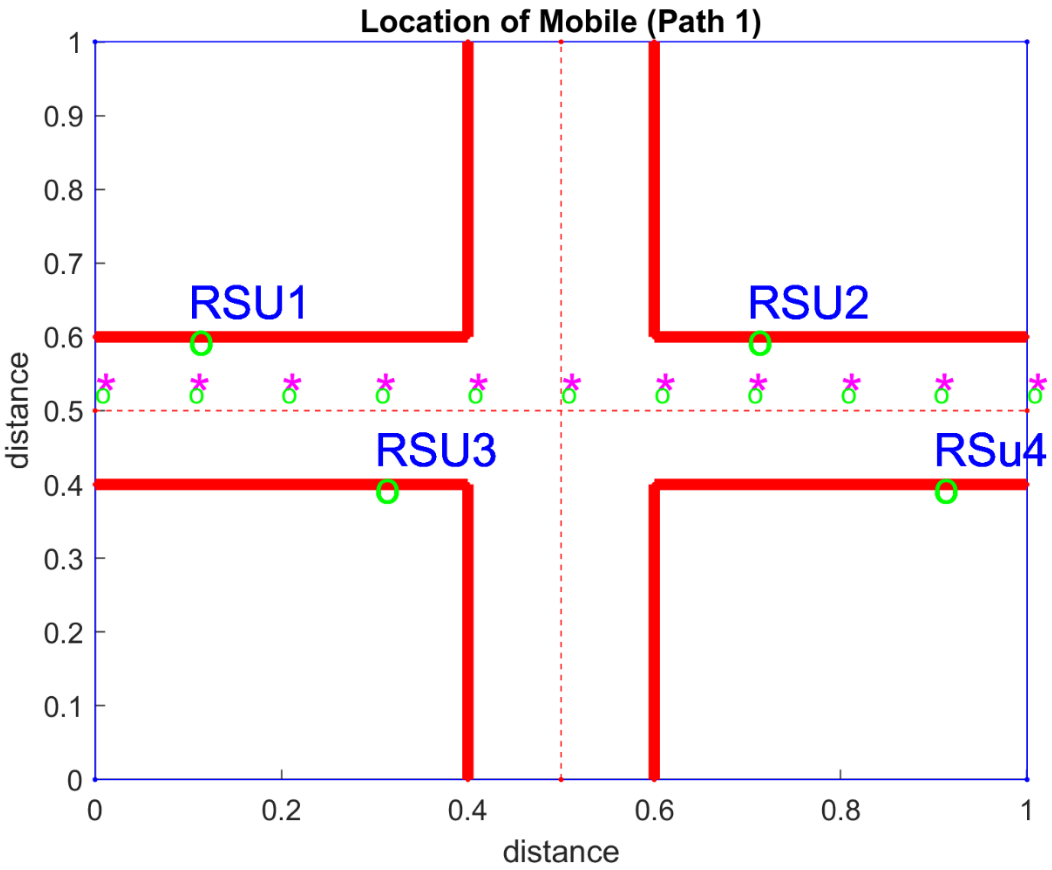

Figure 27. Path 1 Position Location

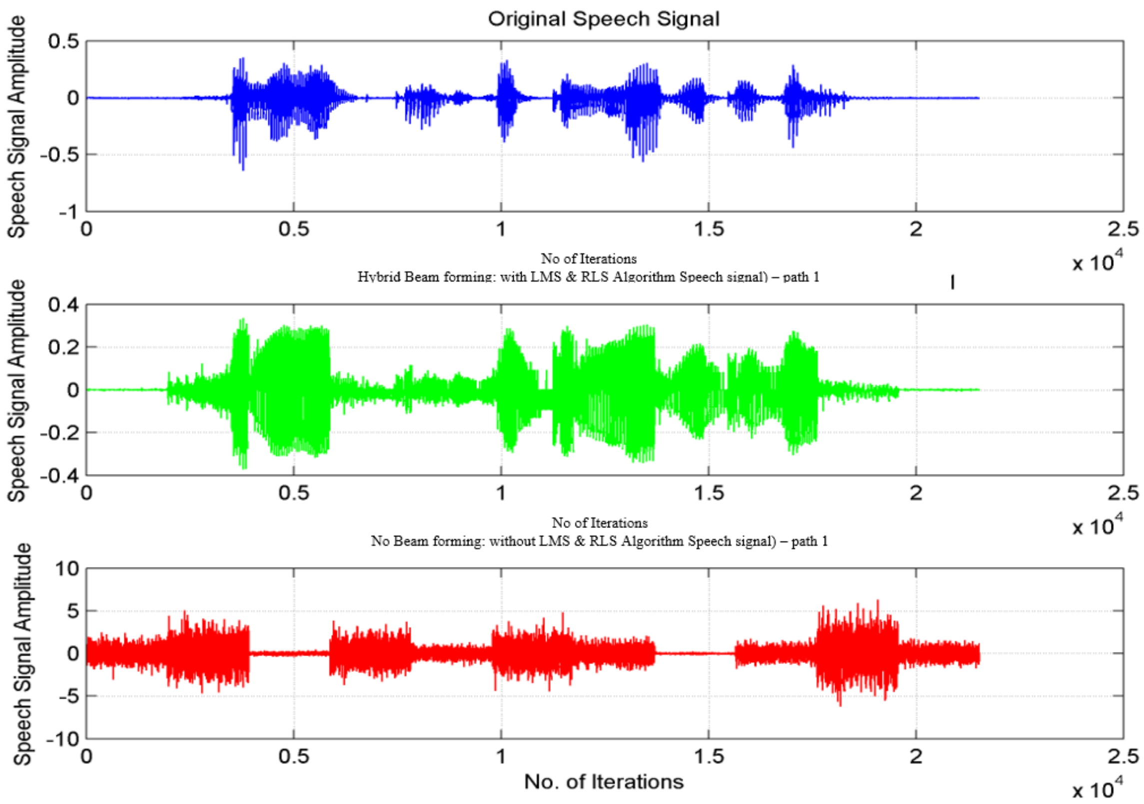

Figure 28. Hybrid Beam forming Speech signal

6. Conclusion

This paper presents a detailed Performance Analysis of Adaptive beamforming Techniques on MMSE, CGM, LMS, SMI, RLS, CMA, LSCMA, DLSCMA, and Hybrid Beamforming. We designed and executed an efficient, optimum, less time consuming, strong, safe, and economical method of cancellation interference signals from various interferers coming through different angles or directions using a hybrid adaptive/fixed beam forming techniques which is suitable for Vehicular environment. In the future, we can implement this Hybrid Adaptive beamforming approach on routing and security purposes for suitable VANETs environments.

References

7. Godara, L., “Application of Antenna Arrays to Mobile Communications, Part II: Beam-Forming and Direction-of-Arrival Considerations,” *Proceedings of the IEEE*, Vol. 85, No. 8, pp. 1195–1245, 1997.
8. Johnson, D., “The Application of Spectral Estimation Methods to Bearing Estimation Problems,” *Proceedings of the IEEE,* Vol. 70, No. 9, pp. 1018–1028, Sept. 1982.
9. Van Trees, H., *Optimum Array Processing: Part IV of Detection, Estimation, and Modulation Theory,* Wiley Inter Science, New York, 2002.
10. Shan, T-J., M. Wax, and T. Kailath, “Spatial Smoothing for Direction-of-Arrival Estimation of Coherent Signals,” *IEEE Transactions on Acoustics, Speech, and Signal Processing,* Vol. ASSP-33, No. 4, 806–811, Aug. 1985.
11. Minasyan, G., *“Application of High Resolution Methods to Underwater Data Processing,”* Ph.D. Dissertation, N.N. Andreyev Acoustics Institute, Moscow, Oct. 1994.
12. Schmidt, R., “Multiple Emitter Location and Signal Parameter Estimation,” *IEEE Transactions on Antenna. Propagation.*, Vol. AP-34, No. 2, pp. 276–280, March 1986.
13. Applebaum, S., “Adaptive Arrays,” *Syracuse University Research Corporation, Rep. SPL TR66-1,* August 1966.
14. Widrow, B., P. Mantey, L. Griffiths, et al., “Adaptive Antenna Systems,” *Proceedings of the IEEE,* Vol. 55, Dec. 1967.
15. Gabriel, W., “Adaptive Processing Antenna Systems,” *IEEE Antenna and Propagation Newsletter,* pp. 5–11, Oct. 1983.
16. Agee, B., “The Least-Squares CMA: A New Technique for Rapid Correction of Constant Modulus Signals,” *IEEE International Conference on ICASSP ’86,* Vol. 11, pp. 953–956, April 1986.

17. Sorenson, H., "Least-Squares Estimation: From Gauss to Kalman," *IEEE Spectrum,* Vol. 7, pp. 63–68, July 1970.
18. Monzingo, R., and T. Miller, *Introduction to Adaptive Arrays, Wiley Interscience, John Wiley & Sons,* New York, 1980.
19. Liberti, J., and T. *Rappaport, Smart Antennas for Wireless Communications: IS-95 and Third Generation CDMA Applications,* Prentice Hall, New York, 1999.
20. D. Rajaveerappa and Fituri H. Belgassem, "A Two Ray Propagation Model for Finding Mobile Location Over Microcellular Environment", *International Conference on Computer and Communication Technology 2010 (ICCCT2010),* (IEEE Explore) IEEE Computer Society, MNNIT, Allahabad, India, Sept., 2010.
21. D. Rajaveerappa and K. Siddappa Naidu, "Diffraction Propagation Model for Finding Mobile Location Over Rough Surface Adhoc Microcellular Environment", *International Conference on Smart Technologies for Materials, Communication, Controls, Computing & Energy 2011 (ICST2011),* VELTECH University, Chennai, India, Jan., 2011.
22. K Suresh Kumar Reddy, D. Rajaveerappa, "Design and Development of an Efficient Location Based Bandwidth Allocation Method for Wireless Mobile Networks", *International Journal of Control Theory and Applications (ISSN: 0974-5572) (Scopus),* pp. 141-151, vol.10, No.13, April 2017.
23. D. Rajaveerappa and M. Sreenivasan, "Design and Development of a Hybrid SDMA/CDMA MAC Protocol for Wireless Mobile Computing Networks", *The Sixth International Conference/Exhibition on High Performance Computing in Asia-Pacific Region (HPC ASIA 2002),* pp. 561-562, vol.2, 2002.
24. K Suresh Kumar Reddy and Tamizhazhagan, "An Eloborative analysis of bearing estimation techniques for VANETs", *Journal of Advanced Research in Dynamical and Control System,* 1457-1466, Vol. 11, NOV 20119.
25. Reddy K.S.K., Tamizhazhagan V. (2020) An Innovative Selection of Road Side Unit Emplacement in VANETs. In: Karrupusamy P., Chen J., Shi Y. (eds) Sustainable Communication Networks and Application. ICSCN 2019. *Lecture Notes on Data Engineering and Communications Technologies,* vol 39. Springer, Cham. https://doi.org/10.1007/978-3-030-34515-0_39.